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Notice of Exhibit

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

FIFTIETH ANNUAL MEETING

Indianapolis, Ind., December 1937

In connection with the annual meetings of the American Association for the Advancement of Science, there will be the usual general exhibition. Entomologists are requested to participate.

Correspondence concerning space and other information should be addressed to F. C. Brown, Director of Exhibits, Smithsonian Institution Bldg., Washington, D. C.

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OF ECONOMIC ENTOMOLOGY
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AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

PAPER-READING SESSION, FORTY-NINTH ANNUAL MEETING

Atlantic City, N. J., December 1936

Experiments to Control Sugar Beet Leafhopper, 1936

L. W. CAMPBELL, *San Francisco, Calif.*

ATOMIZED toxic spray oils have been used commercially for the control of grape leafhopper and sugar beet leafhopper for the last five years. The writer conducted field tests with an atomizer on grapes for grape leafhopper and on peas for pea aphis early in 1931. Since that time materials and machines have been improved to the point that field demonstrations conducted in 1936 gave almost perfect control.

One application was made on the Hotchkiss ranch, Firebaugh, Calif., for the control of sugar beet leafhopper by the Hawke Crop Dusting Company airplane. An 80-acre field was sprayed under somewhat adverse conditions. The temperature at the time was 65° F with an 8-mile an hour wind prevailing. The field contained beets in various stages of development, some with two to three leaves, others with as many as 19 leaves. U. S. No. 34 seed had been planted. The larger beets were scattered throughout the entire field but were very prominent in the center of the tract. Counts were made 24 and 72 hours after application to determine the control and reinfestation. Twenty-five counts were made per block to determine the average infestation. Only females were recorded.

Populations present per beet before spraying as determined April 27 at 3 to 4 p.m., showed $4.28 \pm .317$. Spraying was done between 8 and 9 a.m. on April 28, using 4.1 gallons of material per acre. Leafhoppers per beet after spraying as determined April 28, 2 to 3 p.m. for all areas treated, are as follows:

Before	$4.28 \pm .317$
After	$.52 \pm .322$
Decrease	87.8 per cent

In this demonstration two types of materials were used. First an oil–kerosene–pyrethrum mixture made up using a kerosene type oil blended with an oil having a viscosity of approximately 60 seconds to make an ultimate product of 34 seconds viscosity, Saybolt Universal, and con-

taining 4 per cent of a 20:1 pyrethrum extract; second, an oil having a viscosity of approximately 38 seconds Saybolt Universal containing 4 per cent of a 20:1 pyrethrum extract.

The second demonstration applied on the properties of the Union Sugar Company of Betteravia, Calif., 5 gallons of sugar beet leafhopper spray having a viscosity of 36 seconds and a pyrethrum content of 4 per cent of a 20:1 pyrethrum extract. This was applied on the afternoon of April 30, temperature prevailing 84° F, average infestation 4.3 hoppers per beet, and gave a control of 97.6 per cent, counts being made in 24 hours. Duplicate tests were made using a ground vaporizing machine of the Johnson type applying 5 gallons of the same type of material per acre, gave a 98.2 per cent control. In commercial applications, the airplane covers 105 to 120 acres per hour and the ground vaporizing machine sprays 60 to 90 acres per day.

Idaho, in conjunction with the U.S.D.A. Sugar Beet Insect Laboratory at Twin Falls, Idaho, conducted numerous tests with a ground vaporizer, Johnson type, during the spring of 1936 with very satisfactory results on the sugar beet leafhopper.

In the experimental work with the vaporizing applicators, the materials were developed to give maximum efficiency. The efficiency of a material depends primarily on its adaptability to atomize or fog and secondarily on its ability to incorporate the proper type and amount of toxic materials. The first work done along this line in 1931 showed that in the ground "compressor type" atomizer approximately 10 per cent of a white neutral oil added to the kerosene type carrier gave the best type of fog.

With the duster or blower variety of vaporizers being developed, it was found that an additional amount of neutral oils had to be added to secure the proper atomization. With some types of blower vaporizers it is necessary to blend as high as 50 per cent white neutral oils of approximately 60 seconds viscosity, Saybolt Universal, to secure the desired fog. This same problem was presented when the airplane was used for application purposes. With little experimenting, the correct amount of neutral oils to be added to make the spray atomize correctly can be determined. The kerosene type oil is basically the carrier of the toxic materials. The white neutral oil is used to retard the evaporation of the kerosene and as a filler or base to assist in atomization and to relieve the possibility of injury.

One of the final tests to make to determine whether the spray and equipment are functioning properly so far as the "fogging" is concerned, is to pass your hand through the fog rather rapidly a short distance, approximately three feet from the nozzle, and if your hand has a wet appearance, you do not have the proper type of atomization.

As a result of the last five years of operations with the various types of vaporizers, the materials and the equipment used for vaporizing the spray materials have been so developed that successful commercial control of the sugar beet leafhopper is assured. Approximately 98 per cent control of the sugar beet leafhopper was secured on 450 acres of sugar beets at different stages of development during 1936.—7-27-37.

Feeding Predetermined Doses of Poison to Silkworms

J. W. Bulger, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*[1]

The so-called sandwich method of Campbell & Filmer (1929), modified by the writer (Bulger 1932), has been used in this laboratory for several years for determining the median lethal dose of powdered stomach poisons for leaf-eating insects, particularly the silkworm. The leaf sandwich offered to the insect contains a known weight of dust uniformly distributed between the two layers. The dose taken by the insect is therefore proportional to the area eaten out of the total area of the sandwich. The dose consumed can be controlled only in a rough way by

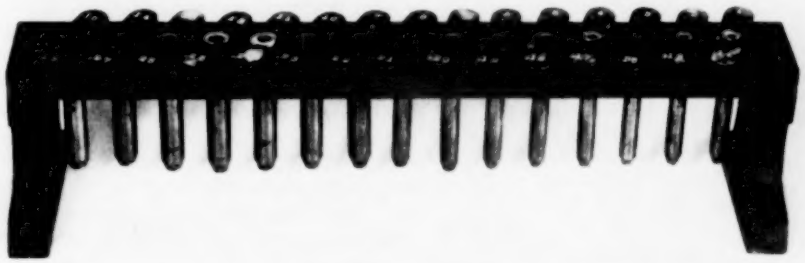

Fig. 1.—Set of carefully milled cutters for cutting leaf inlays.

taking the sandwich from the insect when it appears to the eye that the desired portion of the total area has been eaten. It is then necessary to determine the exact area consumed by some form of direct measurement, *e.g.*, by planimeter (Campbell & Filmer 1929), by photoelectric cell (Bulger 1935), or by cross-section paper (Hansberry & Richardson 1936). All such measurements are tedious and time-consuming, and not all the results of the measurements contribute to the location of the median lethal dose, because some doses turn out to be unnecessarily large or small.

In their description of the sandwich method Campbell & Filmer (1929) said, "The chief defect of this or of any leaf area method is that doses cannot be accurately predetermined. Time and insects are wasted in feeding lethal or sublethal doses which do not help to delimit the M.L.D. It would be desirable to force a predetermined dose directly into the alimentary tract of an insect."

Recognizing the desirability of administering predetermined doses for the estimation of median lethal doses, the writer has further modified the sandwich method so that predetermined doses may be taken by the insects while feeding normally.

Method.—The principle of the method is to place the desired dose of

[1] The writer acknowledges the suggestions and material assistance of F. L. Campbell in the solution of this problem, and the assistance of Mrs. A. H. Casanges in the preparation of leaf sandwiches.

insecticide on a small portion of the leaf area offered to an insect and in such a position that the insect will be likely to eat the entire area covered by the dose and hence to take the entire predetermined dose.

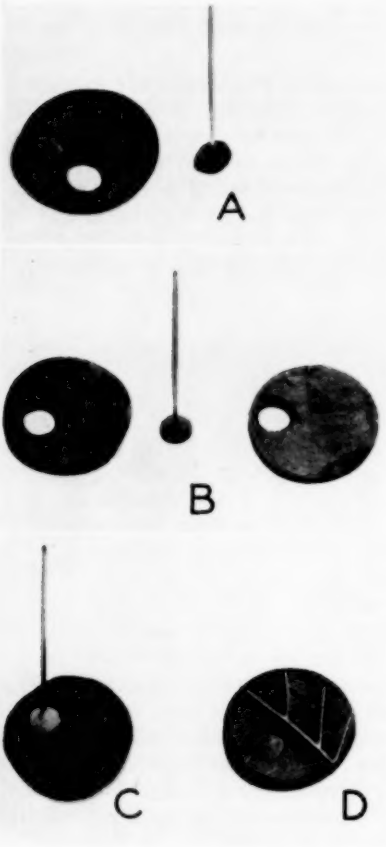

Fig. 2.—Steps in preparation of an inlayed leaf sandwich.

This principle has been applied to insoluble solid insecticides by Cook & McIndoo (1923) and by Campbell & Lukens (1931), who fed entire dried drops of lead arsenate suspensions to silkworms. It is not easy, however, to control and determine the quantity of a substance in a measured drop of a suspension in which the substance is settling. It seemed more practicable, therefore, to apply the usual dust-settling procedure of the sandwich method and to cut out of a dusted leaf disk or sandwich an area calculated to bear the desired dose. It would then be necessary to offer this small dusted leaf area to the insect in such a way that it would be likely to consume it completely.

For a given dose per unit weight of insect, the area to be cut out of the dusted leaf depends on the concentration of dust and the weight of the insect. Both factors can and must be controlled, because the range of usable areas is limited. Areas may be too small to handle or so large that the insects are not likely to consume them completely. Concentration of the dust deposit can be controlled by regulating the charge of dust, air pressure and period of settling, and the weight of the insects can be governed by selection.

In order readily to excise different areas of leaf within a limited range, use was made of a series of 15 carefully milled steel cutters, shown in fig. 1. Their diameters ranged from 3.6 to 7.1 mm., increasing in equal increments of .254 mm. (.01 inch). The area needed for a desired dose, and hence the cutter to be used, can be rapidly calculated by slide rule,[2] or complete tables relating size of cutter to dose, concentration of dust and weight of insect can be prepared in advance.

It was not immediately apparent how to offer small dusted leaf disks to insects so that the majority of them would be completely consumed.

[2] The leaf area (sq. cm.) to be cut equals DWA/w, where D is the dose desired (mg./gram), W the weight of the insect (grams), A the area of the dusted surface weighed (sq. cm.), and w the weight of this dust (mg.).

At first small sandwiches were excised from the regular 22-mm. sandwiches and were stuck on the surface of an untreated 22-mm. leaf disk. Although silkworms will eat three layers of leaf at once, the small sandwich standing on the surface of the larger leaf disk seemed to have the deterrent effect of a heavy vein. Few insects would consume it completely. The procedure was then modified successfully as shown in fig. 2. First the selected cutter was used to excise a disk from an undusted 22-mm. leaf disk as shown in *A*. Then the same cutter was used to excise a disk from a dusted 22-mm. disk shown in *B*. In both *A* and *B* care was taken to cut areas free from the larger veins. To prevent the disk from sticking in the cutter, the center of the area to be excised was held to the linoleum cutting board by a fine needle and the cutter was lowered to the leaf around the needle. After the cut was made, the cutter was lifted vertically away from the needle, and the annular portion of the dusted 22-mm. disk was also lifted over the needle with forceps, leaving the small dusted disk impaled on the needle as shown in *B*. Then the annular portion of the undusted 22-mm. disk, shown in both *A* and *B*, was carefully lowered about the needle so that the small dusted disk filled the cavity in the larger undusted disk as shown in *C*. The needle was then removed from the small dusted disk by pressing it lightly with another needle while the first was withdrawn. The use of these needles did not remove a visible quantity of dust from the small disk. The combination disk, shown in *C*, was then covered with a 22-mm. leaf disk smeared with starch paste, the usual procedure for making a leaf sandwich. The resulting sandwich, turned over to show the back of the dusted inlay, is illustrated in *D*. Three-quarters of this sandwich was covered by a light double-layered cardboard mask, held together and raised from the surface beneath by means of an electrician's clamp. The quarter exposed contains the poisoned inlay. The whole preparation, which is placed in a covered Petri dish with a weighed silkworm, is shown in fig. 3.

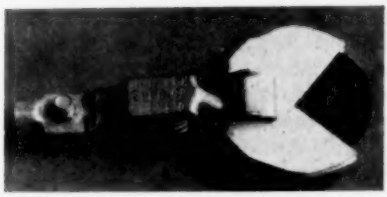

Fig. 3.—Guard and clamp holding completed sandwich ready to be offered to an insect.

Discussion.—To distinguish this modification of the sandwich method from the original method and other modifications, it may be called the inlay sandwich method.

The use of the poisoned inlay in a double-layered leaf sandwich has more than one advantage. As the poisoned area has the same thickness as the rest of the sandwich, larvae are not deterred from biting into it and continuing to feed. The inlay, fitting snugly into the hole prepared for it, is well supported so that no portion of it can readily drop off and be lost while the larva is feeding. When the entire inlay has been consumed one can be certain that the larva has taken the entire dose. The masking of three-quarters of the sandwich reduces the leaf area available to the insect and increases the probability that it will consume the entire dose. Any larva that does not consume the entire dose in a reasonable time is discarded.

The practicability of the inlay sandwich method was tested by using it to redetermine the median lethal dose of acid lead arsenate for the fourth-instar silkworm. Forty silkworms, ranging in weight between .3 and .39 gram, were each offered an inlayed dose of .09 mg. per gram of body weight. Of these, 28 consumed the entire dose; 17 died and 11 survived. Since more than 50 per cent of the larvae that took the entire dose were killed, a smaller predetermined dose was tried. In this test 20 worms were offered a dose of .08 mg. per gram. Of these, 14 consumed the entire dose; five died and nine survived. These results, obtained in a relatively short time, indicated that the median lethal dose lay between .08 and .09 mg. per gram, agreeing well with the previous determinations of Campbell (1930), Bulger (1932), and Hansberry & Richardson (1936), all of whom placed the median lethal dose of acid lead arsenate for fourth-instar silkworms at approximately .09 mg. per gram of body weight. Additional tests of the inlay sandwich method with a number of dustable insecticides were made with a high degree of success. In most tests 60 to 75 per cent of the worms that fed consumed the entire dose of poison.

When the median lethal dose of a material of unknown toxicity is to be determined, preliminary tests must be made to get some indication of its magnitude. The inlay sandwich method makes possible application of a graduated wide range of doses by using simultaneously each of the 15 cutters with one or more concentrations of dust per unit area of leaf.

The inlay sandwich method will be most successful with the more toxic insecticides, which do not require a heavy deposit of dust on the inlay. With the less toxic materials the deposit may have to be made so heavy that the inlay cannot be cut or handled without loss of material, and when the sandwich is made, the heavy deposit on the inlay may be squeezed out beyond its periphery. The writer believes that the inlay sandwich method should not be applied to materials having a median lethal dose greater than .7 mg. per gram.

The inlay sandwich method is subject to some of the errors of the original sandwich method and also to errors in dose that occur when the area of leaf to be excised is not exactly the same as the area of any one of the series of cutters. It is then necessary to choose a cutter having an area nearest to that desired. In the present work the maximum error due to the use of cutters of fixed, discontinuous area is 7 per cent from the smallest cutter, decreasing to 3.6 per cent from the largest. Because of these errors and others resulting from lack of uniformity in concentration of the dust deposit over the dusted leaf disks, a median lethal dose should be determined and expressed in not more than two significant figures. Usually one significant figure is indicated. For example, in determining the median lethal dose of acid lead arsenate, doses of approximately .09 and .08 mg. per gram of body weight were offered. With a suitable concentration of dust and a given weight of insect, the cutter used for a dose of .09 mg. was always one step larger in the series than that used for .08 mg. However, with a high concentration of dust, it might be necessary to use one of the smallest cutters for both these doses. Whether it would be desirable to decrease the increments in area of the cutters (increase the number of cutters in a given range of area) or to

devise a cutter of adjustable area would depend on the extent of other errors in the method. As nearly as the writer can ascertain, in practice the average errors of the original sandwich method and the inlay sandwich method are about equal.

Theoretically, the median lethal dose of a sample of a powdered insecticide should depend partly on the sizes of particles composing it. In the original sandwich method and in all its modifications that make use of the settling of a dust cloud to get a uniform deposit of insecticide, only the smaller particles that settle slowly are collected and offered to the insects. This partial elimination of the factor of particle size may be regarded as a virtue or a deficiency of the method according to the point of view. The next advance in method should make possible the administration of predetermined doses that are representative of the original sample with respect to particle size.

Summary.—A method is described for administering predetermined doses of powdered insecticides to the silkworm. This modification of the leaf-sandwich method is named the inlay sandwich method.—7-26-37.

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Tests on Baits for Oriental Fruit Moths, 1936

S. W. Frost, *The Pennsylvania State College, State College, Pa.*[1]

Forty chemicals were tested as attrahents for the adults of the oriental fruit moth, *Grapholitha molesta* Busck. Wide-mouth glass quart jars were used as traps. A 1:20 solution of medium grade refiner's syrup, sucrose 37.9 per cent and reducing dextrose 19.4 per cent, was used as a bait to which the various attrahents were added at the rate of 1 cc. or 1 gram per trap. Furfural, propyl acetate, citric acid, oxalic acid, succinic acid, acetic acid, tartaric acid, sodium arsenite, sodium oleate, potassium cyanide and soap, being readily soluble in water, were added directly

[1] Authorized November 3, 1936, for publication as paper 743 in the journal series of the Pennsylvania Agricultural Experiment Station.

Table 1.—Chemotropic responses of the oriental fruit moth, 1936.

Attrahents	No. Moths Taken from 10 Traps				
	May–June	June–July	July–Aug.	Aug.–Oct.	Total
Safrol, monthly	39	18	25	47	129
Safrol, weekly, Check S	57	143	43	119	362
Safrol, weekly, Check N	42	355	170	175	742
Safrol, weekly, Check M	122	201	80	111	514
Anethol	151	216	68	137	572
Eugenol	85	253	89	316	743
Linalool	71	92	44	104	311
Eucalyptol	130	65	93	159	447
Furfurol	48	46	26	46	166
Geraniol	19	95	62	104	280
Propyl acetate	84	69	97	162	412
Amyl acetate	105	53	54	144	356
Terpinyl acetate	340	187	135	84	746
Ethyl cinnamate	67	219	69	184	539
Amyl salicylate	68	79	83	43	273
Formaldehyde	23	55	59	70	207
Anisic aldehyde	22	86	31	45	184
Citric acid	125	115	76	114	430
Oxalic acid	102	166	94	77	439
Succinic acid	104	110	98	116	428
Camphoric acid	80	101	34	90	305
Salicylic acid	118	116	90	82	406
Anisic acid	93				93
Acetic acid	129	181	109	101	520
Linolic acid	40	140	72	407	659
Oleic acid, Comm.	72	108	118	428	726
Oleic acid, U.S.P.	57	233	122	351	763
Oleic acid, linolic free	72	191	102	363	728
Tartaric acid	240	195	149	136	720
Sodium oleate	87	212	97	257	653
Potassium cyanide	108	139	80	156	483
Acetone	157	251	77	152	637
Soap	93	175	72	178	518
Borneol	58	128	16	139	341
Pinene	129	100	28	195	452
Piperonal	13	46	25	33	117
Citral	36	135	59	178	408
Anis seed oil	84	217	53	115	469
Fennel seed oil	69	211	38	183	501
Pine oil	63	147	25	184	419
Turpentine	130	79	50	121	380
Linseed oil	60	67	30	99	256
Totals	3792	5795	2942	6305	18834

to the syrup solution. Anisic acid, camphoric acid, borneol and piperonal were dissolved in alcohol before adding to the baits. All other chemicals were emulsified using 10 grams of acacia, 80 cc. of water and 10 cc. or 10 grams of the attrahent, making sufficient stock for 10 traps. It has previously been shown that acacia is not noticeably attractive to the orien-

tal fruit moths and therefore is an excellent emulsifying agent for the purpose.

Ten traps were used in each test recorded in tables 1 and 2 and corrections have been made for traps that fell during the course of the experiments. Three sets of check traps with safrol were run for the entire summer, one set at each end of the baited orchard and one set in the middle.

The oriental fruit moth population was generally low during the summer. The catches for 1936 were below the average for the last five years and too low to draw satisfactory conclusions. There was some variation in the checks ranging from 362 to 742 moths which indicates an uneven distribution. The original position of each check trap was maintained throughout the summer while the other traps were moved one row each week to compensate, in a measure, for variations in moth distribution.

Table 2.—Leading attrahents for 1936.

Attrahent	No. Oriental Fruit Moths Taken From 10 Traps	Cost per Trap
Oleic acid, U.S.P.	763	.0008
Terpinyl acetate	746	.0077
Safrol	742	.0022
Eugenol	743	.0071
Oleic acid, linolic free	728	.0143
Oleic acid, commercial	726	.0029
Tartaric acid	720	.0009
Linolic acid	659	.2250
Sodium oleate	653	.0016
Acetone, U.S.P.	673	.0011

The ten leading materials for 1936 are listed in the order of their attractiveness. During 1935, acetic acid, anethol, anisic aldehyde and linseed oil were among the 10 best materials. While these were tested in 1936, the last three appear far down the list. Certain materials are more attractive at one season of the year than another. Terpinyl acetate, for example, exceeded the catch of any other material during May and June but the catches during the remainder of the summer were below the average. The acids and sodium oleate were more attractive during August, September and October, although tartaric acid was an exception. Terpinyl acetate, oleic acid and safrol have for years been the leading attrahents. Most of the materials are inexpensive, costing less than one cent a trap. Linolic acid, while very attractive, is too expensive for practical use.—8-1-37.

Life History Notes on *Eriopyga incincta* (Morr.)[1] in Kansas

H. H. Walkden, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Eriopyga incincta (Morr.) is one of the many species of cutworms which attack cereal and forage crops in the middle west, but only occasionally occur in sufficient abundance to cause noticeable damage. The only reference dealing with this species known to the writer was published

[1] Order Lepidoptera, family Noctuidae.

by Wadley (1920), who recorded the larvae of *E. incincta* as injurious to alfalfa and garden crops at Wichita, Kan., in the spring of 1920. Since that time the writer has accumulated considerable information on the species. This paper presents a summary of these observations.

Synonymy and distribution.—The species *Eriopyga incincta* is quite variable in superficial characters of color and markings and in consequence has been described under several different names. According to Heinrich (in personal correspondence) the name *incincta* is the oldest of this group and therefore is preferred. A study of the synonymy of the species of *Eriopyga* was being made by F. H. Benjamin at the time of

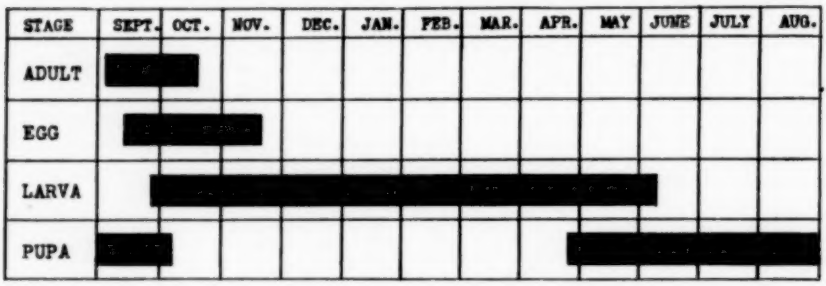

Fig. 1.—Seasonal history chart of *Eriopyga incincta* in Kansas.

his death, but unfortunately it was not completed. Further study is required before the synonymy of this species can be definitely established.

According to the records of the Bureau of Entomology and Plant Quarantine the species ranges from Illinois to the Pacific coast.

The writer has taken adults at Cherryvale, Manhattan, Hays, Garden City and Wichita in Kansas, and at Lincoln and Scottsbluff in Nebraska. It would therefore appear that the species is generally distributed in the central Great Plains region.

Host plants.—All of the larvae collected in these studies were taken under surface trash along roadside hedges and in grassy areas where the predominant grass species was little barley, *Hordeum pusillum* Nutt. In captivity the larvae fed sparingly on alfalfa and wheat leaves, but when offered a choice of all three foods they preferred the kernels of sprouted wheat.

Seasonal history.—In the region where these observations were made the species has but one generation annually. In Kansas the adults appear early in September but in western Nebraska the emergence is somewhat earlier, the first adults at Scottsbluff having been noted on August 2. The heaviest flight of the moth usually occurs during the last two weeks in September. In captivity the females deposit their eggs singly just beneath the surface of the soil, or scatter them promiscuously over the surface. The young larvae emerge from the eggs in eight to 32 days, depending on the temperatures prevailing during the incubation period. They feed to some extent late in the fall, and pass the winter as partially grown larvae. No doubt a limited amount of feeding occurs during mild periods throughout the winter months. With the coming of warm

weather in March or early in April feeding is resumed and by May 15 practically all of the larvae are fully grown. Shortly thereafter, the larvae enter the soil, construct pupal cells of silk mixed with soil, and by May 30 have transformed to the pupal stage. June and July are passed as pupae, and in August and September, depending on locality, the adults emerge, thus completing the seasonal cycle. The seasonal history is shown in fig. 1.

Life cycle. ADULT.—The adults appear to be short lived. Altogether, 18 adults of unknown age taken at a baited trap were caged for oviposition during the course of these studies. The longest period of life after

Table 1.—Summary of measurements of width of head capsule in millimeters in the different instars of larvae of *Eriopyga incincta*.

INSTAR	NO. HEADS MEASURED	MAXIMUM WIDTH	MINIMUM WIDTH	AVERAGE WIDTH
First	170	.45	.35	.38
Second	159	.55	.4	.5
Third	169	.8	.5	.69
Fourth	132	1.05	.75	.9
Fifth	120	1.4	.9	1.21
Sixth	127	2.1	1.2	1.76
Seventh	50	2.2	1.8	2.08
Eighth	0*			

* No measurements of the final instar were made owing to the fact that in the final larval molt the head capsule splits, and accurate measurements are not possible.

capture was 10 days and the shortest four days, the average being five days. Oviposition occurs late in the afternoon and at night. Three females taken on the morning of October 9 were caged, and at 4 p.m. the same day were observed depositing eggs in and on the soil at the bottom of the cage. With wings aflutter and ovipositor exserted, they ran rapidly about the cage, pausing frequently to deposit one or several eggs among the soil particles. At 6 p.m. oviposition was still in progress, and by morning a large number of eggs had been placed in the soil. The females showed no tendency to oviposit on the foliage or other parts of the alfalfa in the cages.

The actual number of eggs deposited was noted in the case of two of the females taken at the baited trap and placed in individual cages. It is quite likely that these adults had already deposited some of their eggs before capture. One of these deposited 296 eggs and the other 326, the latter having four eggs remaining in the ovaries after death.

In order to obtain information on the probable rate of reproduction, females emerging from a life cycle series were dissected within 24 hours after eclosion, and the eggs contained in the ovaries were counted. Altogether, 21 females were dissected. The largest number of eggs observed was 1173 and the minimum 470, the average for the group being 877.

In numbers, the sexes are apparently about evenly divided. A total of 128 adults was secured in various rearings. Of this number, 66, or 52 per cent, were males. At bait and light traps, however, the males greatly outnumber the females. At bait the proportion was two males to one female, while at lights the ratio was 6:1.

EGG.—Several lots of eggs, deposited on various dates between September 20 and October 23, hatched under laboratory conditions in eight to 32 days, the average incubation period being 19 days. The eggs deposited on September 20 hatched in eight days, and the incubation period for the different lots of eggs gradually increased until those deposited October 22–23 required 32 days. Eggs obtained from the females used for oviposition records were placed in homeopathic vials and, as they

Table 2.—Summary of the life cycle of *Eriopyga incincta* in Kansas.

STAGE	No. SPECIMENS OBSERVED	DAYS SPENT IN PERIOD			
		Maximum	Minimum	Av. Including 16 Emerged in June	Av. of September Emergence Only
		Egg			
	251	16	10	11.8	
		Larval			
First instar	166	23	4	8.3	
Second instar	162	24	4	9.1	
Third instar	159	137	7	26.6	
Fourth instar	141	140	8	84.9	
Fifth instar	136	113	6	29.1	
Sixth instar	133	102	5	12.2	
Seventh instar					
Larvae having only 7 instars	79	49	28	35.6	
Larvae having 8 instars	51	30	8	13.8	
Eighth instar	37	52	23	36.4	
		Prepupal			
	114	26	2	8.6	
		Total Larval			
	116	232	190	212.7	
		Pupal			
	85	124	31	98.1	111.
		Egg to Adult			
	85	360	256	326.3	341.5

hatched, the larvae were removed. It was found that there was a variation of one to five days in the incubation period of eggs deposited on the same date. Of 622 eggs under observation, 93, or 15 per cent, failed to hatch.

LARVA.—In making observations on the larval instars the following method was employed.

As the eggs hatched, the larvae were placed in individual homeopathic vials, a single grain of sprouted wheat being supplied to each for food. The vials were plugged with cotton and put in holes bored in plaster of Paris blocks, the plugged end in contact with the plaster. A supply of moisture was introduced by absorption from the plaster, which was kept saturated with water. This transfer of moisture kept the food supply fresh. If necessary, the food was changed at the time of the daily observation. The larvae were observed daily and the molts and measurements of their cast head capsules recorded. After the third molt the larvae were

transferred to 3-ounce salve tins partially filled with sterilized soil. Several grains of sprouted wheat were placed therein on top of the soil.

Two generations were reared in this manner. The first generation was started with eggs deposited October 3 to 9, 1924. The eggs were incubated at room temperatures and the larvae kept in the laboratory until November 23, when they were placed in an outdoor cave. The winter temperatures in the cave were sufficiently low to induce hibernation but never reached the freezing point. Early in April the larvae were removed to an outdoor insectary and after pupation were again placed in the cave.

The second generation was started with eggs deposited October 6 to 9, 1926, and handled in the way described above, except that the larvae were placed in the cave on November 9 and were kept there for the remainder of the life cycle.

As the larvae molted, the cast head capsules were measured, the greatest width as seen from the front being taken. As will be seen in table 1, the increase in size of head capsule between instars is small. The variation in head size within an instar results in an overlapping of measurements from one instar to the next.

In all cases the larvae ceased feeding late in November and remained inactive during the winter months. During the last of February feeding was resumed, and the larvae were fully grown early in May. By May 30 nearly all had pupated. A summary of the life cycle is given in table 2.

PUPA.—Pupation takes place in the soil in a cell made of silk mixed with soil particles, constructed by the larva shortly after feeding ceases. In the life cycle series a few adults emerged during the last of June but the great majority of individuals passed the summer in the pupal stage, the adults emerging in September. Inasmuch as the pupae were kept in a cave, and consequently were not exposed to the high summer temperature, it is probable that the June emergence was induced by the comparatively cool conditions prevailing in the cave.

A group of 46 pupae, obtained from field-collected larvae, averaged 119.2 days in the pupal stage, the maximum being 146 days and the minimum 87. A group of pupae in the life cycle series averaged 111 days in the pupal stage, table 2. The difference is no doubt due to the fact that the field-collected larvae had been subjected to winter conditions and consequently developed more slowly than larvae in the life cycle series.

Parasites and disease.—The larvae of *E. incincta* were never common in the vicinity of Wichita, Kan., where these studies were made, and as as a result the notes on parasitization and disease are meagre.

Over a period of several years, a total of 102 larvae were collected. Of this number 8 per cent were killed by fungous diseases and 11 per cent by internal hymenopterous parasites, no adults of which were secured.—7-14-37.

LITERATURE CITED

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GEORGIA, on June 8, issued "Standard State Quarantine Order No. 2" relating to the peach mosaic disease, adopting the standard certification requirement of a disease-free radius of five miles around shipping nurseries in the infected states.

SECTION OF APICULTURE

Improved Apparatus for Inseminating Queen Bees by the Watson Method

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Ten years ago L. R. Watson demonstrated before a meeting of the Section of Apiculture at Philadelphia his newly developed method for the artificial insemination of queen bees. Two years later, at a meeting of the same section in New York City, the first verification of the method was announced in a report of work by the Department of Agriculture. Since that time further work by the Department has improved technic and apparatus, and has demonstrated that the Watson method can be utilized in conducting genetical studies on the honeybee, seven successive generations having been reared in three seasons from queens inseminated by this method.

It is not to be inferred that success is now had by the Department with every queen subjected to the Watson method, but there has been an increasing measure of success from year to year. For example, in 1932, worker bees were reared from 50, or 13.6 per cent, of a total of 367 queens operated on. A microscopic examination showed the presence of sperm in the spermathecae of 85 others, thus making the degree of success practically 40 per cent even though no determination could be made in the case of a number of queens lost in various ways. In 1933 worker offspring was reared from 27, or 15.7 per cent, of the season's total of 172 queens, while in 1934 these numbers were 31, or 28.4 per cent, out of a total of 109. Of greater importance is the striking increase during the three years in the number of queens that began their active careers, after being introduced to nuclei, as normally as if they had been naturally mated, at least as regards time of commencing egg laying, compactness of brood nest, and laying only fertilized eggs. The numbers of such queens found in 1932, 1933, and 1934 were 11, 14 and 18, respectively, making the corresponding percentages for each year 2.99, 8.14 and 16.51.

The number of queens successfully operated upon during 1932 to 1934 might have been higher had not attempts to preserve certain strains or make certain crosses occasionally led to the use of drones that did not appear to be in the right condition. Data for 1935 and 1936 are not included, because the work was interrupted in 1935 when the laboratory of the Division of Bee Culture was moved from Somerset, Md., to Beltsville, Md., and it is still in process of being readjusted to meet the honey flows and other changed conditions found in the new location.

Special features of new apparatus.—Improved apparatus has played an important part in the increased success with the Watson method reported here. Some of the special features of this new equipment differentiating it from that developed by Watson are as follows: more than one queen can be operated on at a time; only one microscope is needed in using a large number of syringes; a microsyringe, all metal except for the glass point, has been devised; a cheap and easily made manipulator

is provided for the microsyringe; the queen is held in a glass tube with only her abdominal tips projecting, instead of being bound by thread to a small wooden block hollowed out to fit her body; and the queen's abdominal tips are spread apart by a pair of metal hooks held mechanically instead of by forceps held by hand. Furthermore, the various parts of the equipment are so joined together that a jar on the apparatus will not dislodge the pipette when it is in position in the queen, nor need the operator be present continuously. With this equipment the genital opening of the queen can be found quickly under the microscope, and the

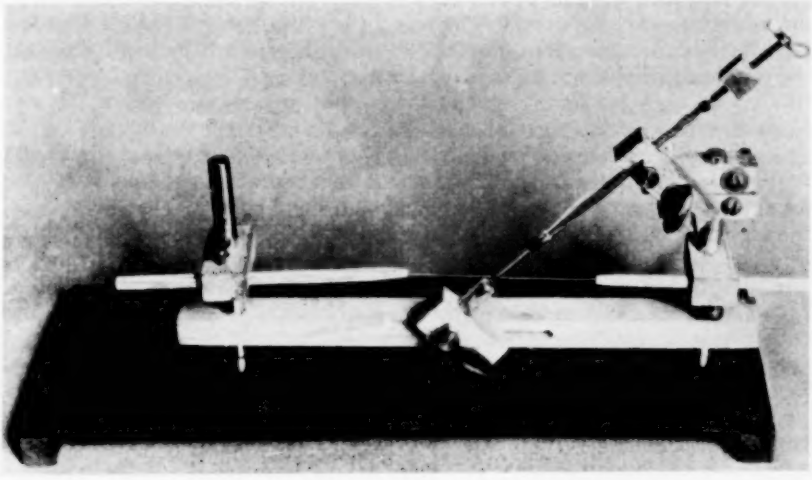

Fig. 1.—A unit of the multiple set-up for the artificial insemination of queen bees.

microsyringe can readily be brought into correct position for discharging the sperm without injury to the queen.

Since this equipment makes possible the insemination of several queens more or less simultaneously through the use of a number of identical units, it is called a "multiple set-up." How many units are to be provided in a set-up will depend upon the skill and convenience of the operator. With a set-up of six units as many as 12 queens have been operated on in one day, but these numbers are not given as maximum limits. Each unit consists essentially of an operating stage, a mount for the queen, holding hooks, a pipette, and a pipette manipulator, fig. 1.

Operating stage.—The operating stage is made of a sheet of metal one-sixteenth of an inch thick, $4\frac{1}{2}$ inches wide, and $12\frac{1}{2}$ inches long, supported at each end by a wooden block just high enough to clear the base of a microscope stand. Instead of wooden blocks for supports, the sheet of metal may be bent over at each end. If desired, the stage can be bolted or clamped to the table or other support on which it rests. Fastened to the stage by nuts are two three-eighth-inch metal rods, 8 inches apart and 4 inches high, which serve as supports for the pipette manipulator and other apparatus.

Mount for queen.—The mount for the queen consists of a strip of

wood one-half by three-quarters by 10 inches, to which is attached by a three-sixteenth-inch thumbscrew and wing nut, a movable wooden block one-half by five-eighths by 1½ inches, supporting a small glass tube, the queen holder. The strip, provided with a hole at each end, fits just snugly enough on the metal rods of the stage to permit being readily pushed up and down on them but to stay at any desired height. Through the center of the strip is a horizontal slot about 2 inches long for the insertion of the thumbscrew and to permit horizontal adjustment of the block.

The glass tube fits into a hole through the block, and is easily removed, but when in position it is held firmly by a thumbscrew with a knurled head. It has an inner diameter of 6–7 mm., is about 2 inches long, and has one end drawn out to permit the abdomen of the queen to project just far enough for the operation to be performed. A wooden stopper keeps the queen from crawling out of the tube. If the stopper is of the right diameter, a piece of rubber band, stretched lengthwise along the stopper as it is shoved into the tube, will hold the stopper in the tube and also permit its easy withdrawal.

The queen can readily be caused to back into the tube by first letting her run into another similar tube. When her head touches the constricted end, she usually begins to back and, if the wider openings of the tubes have been brought together in the meantime, she will continue backing until she is in proper position in the holder.

The mount provides amply for bringing the queen into proper position for easy insertion of the pipette, since the whole mount may be adjusted for height, the small block may be rotated in a vertical plane or moved horizontally in the direction of the long strip, and the tube may be rotated on its own longitudinal axis.

Holding hooks.—Two holding hooks, instruments with a small hook at the end of each and used to hold apart the queen's abdominal tips, are supported above the stage by two wooden blocks (one-half by three-quarters inch, end dimensions, by 1½ inches in length). Each block is fitted to one of the metal rods by a hole of the right size to permit the block to be moved freely on its rod but to stay where put. The handle of each holding hook passes through a hole in its supporting block large enough to permit free movement of the hook when it is being inserted between the queen's abdominal tips, while a thumbscrew is provided to fasten it securely when in position. The queen's ventral abdominal tip is held by one hook and her dorsal abdominal tip by the other. When the pipette is in position, the hook holding the dorsal tip can be withdrawn.

An ordinary transferring needle, such as is commonly used in queen rearing operations, serves nicely as a holding hook. If the point is not at the proper angle it can readily be bent, and if not of the desired thinness it can be filed thinner. A holding hook is also easily made by inserting into a wooden handle a piece of fine spring wire bent into a little hook.

Pipette manipulator.—The pipette manipulator consists of two small wooden blocks (one-half by one-half inch, end dimensions, by 1½ to 2 inches in length) fastened together near one end of each by a three-sixteenth-inch thumbscrew and wing nut. Metal washers are used both

between the blocks and between wing nut and block. A rubber band wrapped about the thumbscrew between the latter washer and block makes possible slight adjustments in the angles between the blocks without loosening the wing nut. The other end of one of the blocks is made into a clamp by boring through it a hole to fit one of the rods on the operating stage and then connecting this hole with the tip by a vertical saw cut. A three-sixteenth-inch thumbscrew and wing nut serve as a means of tightening the clamp, and thus the block can be fastened at any height on the rod and at any horizontal angle. In the free end of the other block is a hole just large enough to permit the pipette to be shoved through freely, a small screw serving to fasten the pipette at the proper position. An additional clamp beneath that holding the manipulator on the rod keeps the manipulator at the proper height when it is being rotated in a horizontal plane.

Pipette.—The pipette is made from an automatic lead pencil in which the lead-moving mechanism consists of a narrow piece of thin metal rolled lengthwise into an open spiral forming a spiral groove in which two tiny knobs attached to the lead holder slide back and forth, causing the lead to go in or out of the pencil as the spiral is turned. A wire plunger is attached to the holder in substitution for the lead, while a plunger barrel is fastened to the point of the pencil.

A piece of bare nichrome, or similar type, wire, of No. 28 gauge, is used as a plunger. Wire of other diameters will serve. Watson wraps a tiny thread around the plunger and shellacks it, but bare wire is satisfactory if it is well vaselined to increase suction.

The plunger barrel is merely a glass point $1\frac{1}{2}$ to 2 inches long. One with an external diameter of 55–60 mm. is preferred, although a barrel with a larger outside diameter can be used. Its interior diameter, of course, depends on the diameter of the plunger wire. It is held in place by minute wooden wedges and deKhotinsky cement. Rubber wedges are also excellent, since they protect the glass point somewhat by adding a degree of resiliency, but it is rather difficult to insert them. Only a portion of the glass barrel about three-eighths of an inch long is left exposed, the remainder being shoved inside the pencil barrel for protection.

The glass points that are to serve as plunger barrels, after being drawn out and cut to proper length, are carefully fire polished at the end through which the sperm is to pass, the operation being checked under a microscope. The polished end reduces the danger of cutting the queen's membranes. The other end is flared to permit insertion of the plunger wire.

Accessory hook.—An accessory hook, made of a transferring needle with point filed thin and bent to fit around the plunger barrel, is useful both in separating the queen's abdominal tips for the insertion of the holding hooks at the beginning of the operation, and in freeing the plunger barrel from the mass of mucus and sperm filling the genital opening at the end of the operation.

Microscope.—A low-power binocular microscope is essential in using the Watson method. There is no set rule about magnification. If only two magnifications are available, one of about seven diameters and one of about 12 diameters are satisfactory.

Lamp.—A microscope lamp is needed. One with an opening in the

shade or reflector through which the microscope can be focused is recommended. No rheostat or resistance coil is necessary with at least one commercial lamp of this type now available, and the heat given off is not sufficient to interfere with the operation. Although one such lamp will

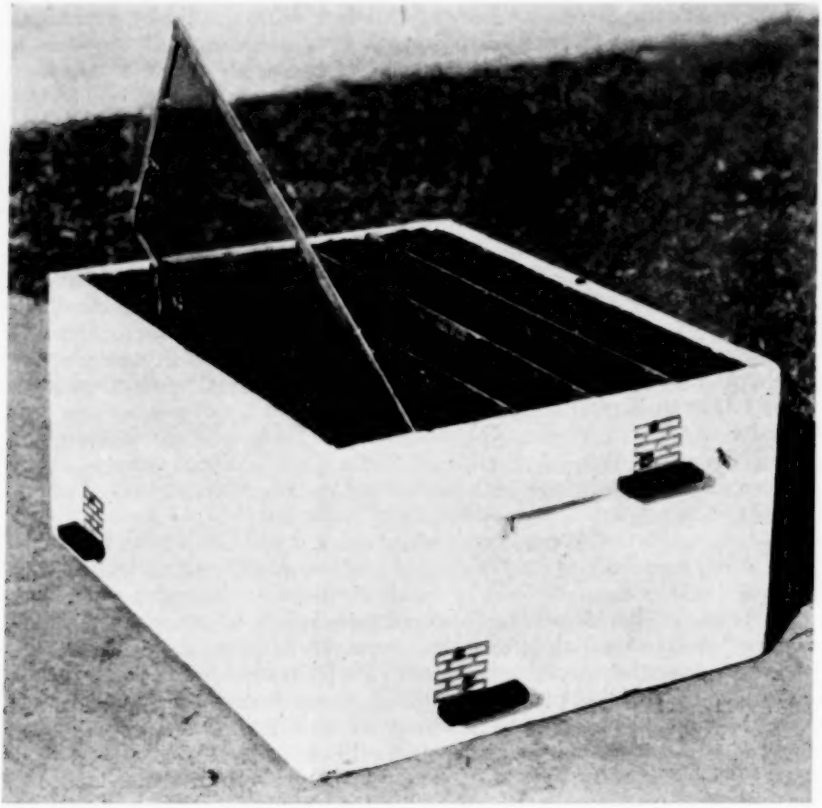

Fig. 2.—Compartment hive body.

suffice for all the units of a multiple set-up if the lamp is shifted from unit to unit as needed, it is much more satisfactory and worth the expense to furnish each unit with its own.

Bee-marking device.—Although not a necessary adjunct of the Watson method, some marking device for drones, queens and workers is essential in any bee-breeding program. A small commercial microsyringe fitted with a fine injecting needle having the point ground off is well adapted for placing even minute dots of paint on bees. A satisfactory paint is made by mixing commercial label varnish with metallic pigments, or with lead oxide, chrome yellow, chrome green, ultramarine blue, zinc oxide and similar pigments.

Queen-testing nucleus.—The use of nuclei in testing inseminated

queens in quantity lots requires fewer bees and less equipment than if full colonies are used. A compartment hive body affords a convenient shelter for a queen-testing nucleus. This is merely a standard 10-frame hive body screened on the bottom and capable of being divided into five bee-tight compartments by removable screening partitions, that is, division boards made of copper screening with tin rims, fig. 2. These partitions slide in grooves cut in the ends of the hive body. Each compartment holds a two-frame nucleus. Such a nucleus can readily be converted into a four-frame or larger nucleus by pulling out the necessary number of movable partitions. Each compartment has its own inner cover and outside entrance. When in use it is set over a full-depth colony.

Even two-frame nuclei in a compartment hive body can be successfully wintered, if they have sufficient young bees and proper stores, by placing a double-wall collar around such a hive body after it has been placed over a colony in a doublewall hive. The original entrance to each compartment is connected with the outside by a piece of tubing of glass or other material, extending through the collar. A sawdust tray and telescope outer cover are placed on top.—1-23-37.

SECTION OF EXTENSION

Value of Coordinating Extension Entomologists and the Bureau

In Conducting Insect Control Campaigns

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During the last three years the Bureau of Entomology and Plant Quarantine has conducted a number of large-scale control campaigns in cooperation with various states. The first of these was the grasshopper control campaign of 1934 which, before completion, included 18 states and cost approximately two million dollars. During the same year a million-dollar campaign for chinch bug control was conducted in cooperation with 11 states. Appropriations were made in 1935 and 1936 for other campaigns of similar nature, including the campaigns for the control of chinch bugs, grasshoppers and screw-worms, all involving close cooperation between state agencies and the Bureau, and requiring extensive organization for effective work on the large scale necessary. These campaigns have given an excellent opportunity to determine the value of close coordination between the Bureau and state extension entomologists and other state agencies.

Coordination of the work of the Bureau with that of extension agencies, including the extension entomologists, has contributed materially to such success as may have been attained by those campaigns with which the speaker has been closely associated. The type of organization

worked out for the grasshopper control campaign of 1934 has been followed with minor modifications in the other campaigns, and the soundness of the organization developed at that time has been quite thoroughly demonstrated where large-scale operations of a cooperative nature are involved. The organization utilized in conducting this campaign has already been described in some detail by J. R. Parker (1935), and will be only briefly reviewed here. In discussing the organization, it is difficult to differentiate between the activity of the extension entomologist as such and the whole Extension Service to which the extension entomologist served as liaison officer and was largely responsible for directing the extension phases of the campaign in each state. It is true that in some cases no extension entomologist was employed by the states cooperating in the campaign; in such cases, however, it was necessary for the duties ordinarily assumed by the extension entomologist to be performed by the state entomologist or some other entomological agent of the state organization. In general, the organization was much easier to complete and operated more smoothly where an extension entomologist was regularly employed by the state and had already made his contacts with county agents and other extension agencies operating within the state.

In brief, the organization utilized in the various large control campaigns has consisted of a state control committee, on which the important interested agricultural agencies in the state were represented. The state director of extension, director of the state experiment station, president of the agricultural college, a representative from the state department of agriculture, and possibly representatives from the governor's office or other organizations were included on this committee according to the individual state set-ups. This committee, upon being approved by the Secretary of Agriculture, was responsible for making application to the Department of Agriculture for federal assistance in control, to establish to the Secretary's satisfaction that federal aid was necessary, and to see that the proper organization was set up within the state to provide adequately for the state's contribution and to meet the requirements of the law with reference to the state's participation in the cooperative activity. The state control committee of each state appointed a state leader, who was directly responsible to the committee for the organization of the campaign within the state subject to advice and approval by the Bureau representatives, and was the officer with whom most of the dealings of the Bureau of Entomology and Plant Quarantine were conducted after the state organization had been approved. The state leader was sometimes the extension entomologist, sometimes the state entomologist, and sometimes an officer from the state department of agriculture. In most cases where a state extension entomologist was employed by the state, he was directly responsible for handling the campaign activity although he might not actually be the state leader.

The type of state organization acceptable to the Department of Agriculture included the full utilization of all extension forces within the state, including the state officers as well as the county agents. This was concurred in by the Director of Extension of the Department of Agriculture and received his full support. Some states were divided into districts, with an assistant state leader in charge of each district. Where

state funds were inadequate to provide the personnel necessary to supervise the control work and conduct the educational activity, assistant state leaders and in some cases county leaders were employed by the Bureau of Entomology and Plant Quarantine but were placed under the direct supervision of the state leader—the Bureau's responsibility for direction of their work, assignment of duties, and determination of methods being discharged through the state leader. States in turn required a definite county organization to be set up by each county before an apportionment of the state allotment was approved for the individual counties. The county organization was usually headed by the county agent. The county agent's entire organization including his community or township committees was made a part of the organization for distribution, mixing and local handling of the control materials after they were laid down at local railway distributing centers. The Department of Agriculture, through the Bureau of Entomology and Plant Quarantine, was responsible for the purchase and distribution of control materials, for the determination of methods and bait mixtures to be used, for the allocation of available materials to the individual states according to the estimated needs and availability of materials, and for the supervision of the entire campaign.

In 1934 funds were available sufficiently early to enable the development of a thorough organization for conducting the grasshopper control campaign. Supervised by the state extension entomologist or other entomological service and assisted by the Bureau specialists, training schools were conducted for the county leaders, who in turn conducted meetings in the heavily infested area which were attended by a large proportion of the farmers. At these meetings methods of control were thoroughly outlined. From this brief summary it may be observed that the Extension Service was really the backbone of the campaign within the states. It was the agency directly responsible for the supervision of the application of the bait material by individual farmers, for its allocation to individuals, and for check on its adequate and proper utilization, for the prevention of waste, and for a final accounting to the state leader of materials used.

There has been the closest kind of cooperation between the Bureau organization and that of the individual states in conducting these campaigns. Coordination of activity has been obtained through numerous meetings of the state and federal officers concerned in the campaign and through individual conferences between the state officers and members of the staff of the Bureau of Entomology and Plant Quarantine, who were kept constantly in the field reviewing infestation conditions and observing methods of application and results, and who kept the entomologists of each state fully informed of new methods and ideas developed in other states for improvement of the activity.

In planning and organizing large-scale campaigns conducted by the Bureau it has been necessary to obtain as accurate information as possible on the extent of infestation, both as a basis for determining the amount of funds necessary to secure adequate control and for the purpose of distribution and allocation of materials after the campaign has been started. In the case of the grasshopper control campaigns and the

1935 chinch bug control campaign, funds were available sufficiently early to permit an adequate evaluation of conditions through field survey. A method of determining grasshopper populations has been developed by the Bureau of Entomology and Plant Quarantine, and since 1933 a population survey has been conducted in cooperation with the state entomologists. As a result, a fairly definite estimation is obtained by early winter of each year of the extent of the infestation of grasshoppers in the more severely infested states and an estimate is made of the amount of materials and the funds necessary to secure adequate control the following spring and summer. The survey conducted cooperatively with the state agencies, which in many cases has meant the extension entomologist, has become an important feature of grasshopper control and enables not only proper planning of campaigns when they are necessary but develops a large body of information on which prevention can be based during times when grasshopper populations are building up but previous to extensive area-wide outbreaks. This survey is coordinated by the Bureau of Entomology and Plant Quarantine through an annual appropriation of $25,000 which was first made available by Congress for grasshopper survey in 1935. In years of extensive outbreak, such as has been experienced during the past few years, this amount has been adequate to cover only the most severely infested states in detail and then only with the extensive cooperation of state agencies. The Bureau of Entomology and Plant Quarantine has assisted the state organization, as far as funds have permitted, by the employment of personnel assigned directly to the supervision of the state officer in charge of the survey–subject to general supervision through the state officer by the Bureau–and by the payment of travel expenses for members of the state staff where it is impossible for these to be provided under state funds. The Bureau has also provided for a unification of the survey activity, so that comparable methods are used by the various states. Such methods as are in general use are adapted for particular conditions of climate and vegetation, and the results from all of the states are analyzed and combined in a general report which gives an estimation of the total amount of materials and funds required to control the grasshopper infestation. The Bureau of Entomology and Plant Quarantine has employed a man to maintain close contact with extension agencies and to assist wherever desired in organizing campaigns within the states, and to maintain contact with the various survey agencies so that the methods can be coordinated and maintained on a uniform basis. It has also employed personnel for the purpose of improving survey technic and methods, and in general organization and coordination of the survey activity. Although close cooperation with the county agents to locate the areas of most severe adult infestation has been found highly desirable, it is believed that for greatest accuracy the survey must be conducted by men who are familiar with grasshoppers and with the special technic developed for surveying their abundance, which is not generally the case with county agents nor do they have the time necessary to devote to this activity in order to secure satisfactory results.

In some cases it has been necessary to enter campaigns with only a general knowledge of the distribution and severity of the infestation. In

these cases the Bureau has been very largely dependent on the information obtained by the extension entomologists in the various states through their ordinary contacts with county agents and with insect conditions in the state. As a rule, for example, the extension entomologists in the states in which chinch bugs normally occur have a fairly good indication of the relative abundance of these insects one year as compared with another and of the general distribution of these pests within the boundaries of the state. In such cases, the extension and other entomologists in the states have cooperated fully with the Bureau in supplying all of the information available on the abundance, distribution and location of the insect under consideration as a basis for estimation of the control requirements and for distribution of the campaign activity. This information has been furnished by the state entomological agencies to the Bureau for combination with that from other states, to obtain a regional picture of the infestation. Quite naturally, this type of information is not so accurate as that obtained by special surveys made possible when funds are available for conducting special examination for the distribution and abundance of a given insect pest. In 1934, however, when a large appropriation was made available for chinch bug control, the information furnished by the various states, obtained almost entirely on the basis of the activity of their extension and other state entomologists, gave a fairly adequate picture of the relative requirements of the states for creosote to construct chinch bug barriers.

Contact between the Bureau representatives responsible for conducting various campaigns and the state agencies has been maintained through correspondence and personal conferences, and through regional conferences between the interested states and the Bureau, to exchange information on methods of control and survey, and on the relative abundance of the insect pests within the various states. These conferences, which have been held annually or more frequently as conditions demanded, have afforded an opportunity for exchange of opinions and for modification of procedure according to ideas contributed by the various entomologists concerned. There has been a general effort on the part of the states to develop uniform methods and to modify their procedures in accordance with the best available information. The general exchange of information and free discussion between the various agencies involved has resulted in an excellent spirit of "give and take" and in the general improvement of technic and procedure, both in the evaluation of conditions and in actually conducting control activities. These conferences have also resulted in a better understanding on the part of the Bureau personnel of special state problems and on the part of the state entomologists of some of the difficulties facing the Bureau in obtaining supplies, making allocations of materials, and in fitting general procedure to individual needs which are inherent in all large-scale operations where the needs of many states must be considered.

Education of individual farmers is an essential feature of every large-scale control campaign. This can be done satisfactorily only through the utilization of the extension organization within the state, through information furnished and disseminated by the extension entomologist. Although the importance of the educational aspects of control campaigns

is fully recognized, a sound continuing educational program during periods of low populations is also essential in any program aiming toward the prevention of insect outbreaks. It is the responsibility of the extension entomologist to stress, to both county agents and individual farmers, the importance of preventive activity. The success or failure in the prevention of outbreaks of such insects as grasshoppers will depend very largely on the success following the efforts of the Extension Service in educating farmers to the importance of preventive activity and in securing their cooperation in stamping out local outbreaks previous to their assumption of regional outbreak proportions. The Bureau can assist in this work in certain instances by keeping the state entomological forces informed of impending outbreaks and by furnishing all pertinent information on the importance of the developing populations in certain areas as related to possible infestation of the regions in which these areas may be located. A continuation of the closely coordinated activity existing during control campaigns to periods of less intense activity is much desired by the Bureau as a means toward securing general application of the preventive principle where its possible success is indicated by research information.

In order to determine the economic practicability of large-scale control operations, information on the damage resulting from insect outbreaks is essential, as is also information on the results, in terms of crop saving accruing from control campaigns. This information can be obtained to best advantage through the extension entomologists in the individual states. Entomologists have generally cooperated in supplying the best information available on losses due to insect attack and crops savings resulting from control campaigns. Although estimates are frequently only approximately accurate, the extension entomologist is probably in the best position to furnish such estimates because of his intimate contact with insect conditions in his state. Information furnished by the state entomologists has been used by the Bureau in attempting to evaluate the results of a number of large-scale campaigns conducted cooperatively by the Bureau of Entomology and Plant Quarantine and to estimate crop losses resulting from extensive insect outbreaks.

The Bureau appreciates the cooperation that has been extended to it by the state extension entomologists and other entomological agencies in conducting various insect control campaigns. It is hoped that the coordination of activity between the work of the Bureau and that of the various state entomological organizations may be continued and extended to include other activities of mutual interest in as satisfactory a way as has been done in the emergency operations connected with large-scale insect control campaigns.—3-15-37.

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Under a North Carolina regulation adopted on May 19, a $5000 bond is required of any nurseryman who promises to spray or service nursery stock, and the bond further requires a guarantee that the stock be true to variety.

A Large-scale Demonstration in Mosquito Control

ERNEST N. CORY and S. L. CROSTHWAIT, *College Park, Md.*

Maryland has a large area of tidal marshes that breed tremendous numbers of mosquitoes. There has been a general apathy up to very recent times in regard to the pest mosquitoes, but more and more of our water fronts are being turned into recreation centers and the inhabitants are becoming conscious of the needs for the control of mosquitoes. Up to the time of the CWA very little work had been done in the state except on the control of malarial mosquitoes by the state department of health. During the CWA we were able to start a considerable number of projects and complete a few. One of these projects was in the neighborhood of Ocean City which lies on an island separated from the mainland by a narrow series of bays and surrounded on three sides by considerable marsh land. We were able to ditch an area on the main land opposite Ocean City and south of the town to approximately 3 miles. There was a noticeable reduction in mosquitoes during the season of 1934 and local people, clubs and civic organizations became interested in having further work done. Accordingly application was made for the location of two CCC camps and these began operations in November 1935.

To make the people of the state conscious of the desirability of conducting anti-mosquito work, particularly against those species that breed in the tidal marshes, it was decided that the work should be confined to one county. Worcester county, in which is located Maryland's only seaside resort, having a population of approximately 1000 people as yearly residents and a large vacation influx during the summer, was selected for the demonstration. There are approximately 20,000 acres of marsh, most of which is salt or brackish marsh, and previous surveys with electric traps have disclosed that approximately 90 per cent of the mosquitoes were species that normally breed in the tidal areas. If all of this breeding area could be ditched it is felt that the practicability of the reduction of pest mosquitoes could be demonstrated. It is hoped that if a definite reduction of mosquitoes is obtained by ditching that the local populace and the vacation visitors will appreciate the value of the work accomplished, and will serve to influence the state to adopt a general anti-mosquito campaign.

The molding of public opinion in favor of anti-mosquito work is the immediate goal. Under Maryland law it is essential that the General Assembly pass enabling legislation permitting the separate counties to levy taxes for the support, on a county basis, of anti-mosquito projects.

Most people are familiar with the methods employed so that it is not necessary to describe them in detail here. However, it might be mentioned that we are cutting, by hand, ditches 20 inches wide and 20 inches deep on 150-foot intervals with outlets, in most cases, to natural streams, or guts, rather than directly to the bays where tidal action would have a tendency to close the entrances by sand. Ditches of this character drain

the sheet water from the marshes between tides and permit the access of minnows to all parts of the marsh during high tide.

Coupled with this large demonstration are a series of smaller demonstrations relating to the wildlife of the marsh areas. There has been considerable criticism of the effect of ditching upon wildlife, but so far as we have been able to ascertain there are no definite ecological records to substantiate or contravert the claims of conservationists. In setting up this demonstration we conferred with all parties in any way interested from the standpoint of insect control, conservation and wildlife, health and drainage, and agreed that we would cooperate with the Biological Survey to the fullest extent. We believe that we have carried out our part of this cooperative agreement in both spirit and letter and we are attempting to gather data to show beyond doubt what the effect of ditching is upon marsh flora and fauna.

Demonstration areas have been set aside on which muskrat catches are known, and these areas have been thoroughly mapped to show the dominant types of plants and the number of muskrat houses. Records are being kept of the pH of the soil and the changes that take place both on open marsh and those areas where dikes have been constructed with tide gates to prevent the flooding of the salt water and to hold the water level of fresh water at various heights. In addition to this type of demonstration, plot seeding with various marsh grasses has been undertaken. Demonstrations have also been conducted of the effect of deep ditching versus shallow ditching into ponds, as compared with unditched ponds, to show how widgeon grass, one of the principal duck foods, is affected. So far shallow ditching, which is the procedure we normally follow, has prevented the drying up of ponds during the period of drought, permitted the access of minnows to feed on the mosquito larvae and has maintained the growth of widgeon grass. Surveys of resident and migratory duck and shore bird populations are being made.

We believe that this is one of the most important demonstrations ever undertaken in Maryland, and it should pay big dividends in greater human and animal comfort, and ultimately in increased land values.—5-18-37.

Intensive Demonstrations in Cotton Flea Hopper Control

R. R. Reppert, *Extension Service, College Station, Texas*

The flea hopper in recent years has come to be recognized as one of the major insects affecting the cotton crop. Many farmers insist that it is responsible for more extensive damage than is the cotton boll weevil.

Entomologists of the experiment station at College Station and of the laboratory of the U. S. Bureau of Entomology and Plant Quarantine, at Port Lavaca, Tex., have carried on extensive investigations of this insect looking to methods of control and are agreed that very finely ground sulfur, preferably conditioned by the addition of a small per-

centage of inert material to prevent the sulfur from lumping, is effective when applied as a dust.

In the experimental work, the cost of dusting, including both sulfur and labor, has varied from $2 to $4 per acre for the season, with a resultant increased yield over that of untreated areas of from 102 to 361 pounds of seed cotton per acre, and with a net monetary profit of from $2.08 to $10.44 per acre.

In the possession of a practical measure of control provided by workers in the experimental field and faced with insistent demands from cotton growers for aid in solving their problem of flea hopper damage, the Extension Service early in the spring of 1936 made arrangements for carrying on demonstrations in control. Dr. F. L. Thomas of the Texas experiment station and K. P. Ewing of the Bureau of Entomology and Plant Quarantine had previously carried on some demonstrations in flea hopper control on farms near their respective experiment stations. Over the state as a whole, however, farmers were so inexperienced in matters relating to it that few could even recognize the pest when they saw it, and we felt that the demonstrations would have to be intensive, and at the same time sufficiently extensive to serve the growers in those parts of the state most seriously affected.

By special arrangements, five men, trained in entomology and especially experienced in flea hopper control measures, were made available to us for carrying out the details of the work in the field.

The area of Texas normally suffering heaviest damage from the flea hopper is that known as the black land area, extending from Dallas and Greenville in the north southwesterly to Corpus Christi and including the coastal area as far east as Houston. Parts of this area lie in five of our extension service districts. The district agents of these five districts were consulted and a limited number of demonstrations offered each. The district agents determined, from their knowledge of conditions, upon the counties in which the demonstrations would best apply, and the agents of these counties were directed to list tentatively four or five growers, who in their opinion, would give the necessary cooperation.

Twenty-six counties were suggested in which demonstrations were to be carried on and in these, 78 farms were finally selected as demonstration farms, of which 58 provided data of importance during the season's work. As the season advanced and cotton approached the size of which flea hopper damage might soon be expected, the entomologists selected for the work were one after the other taken to their respective districts and there, in company with the several county agents to whom they were assigned as coworkers, visisted the tentative demonstration farms previously selected by the county agents, made final selection of those which because of previous cropping history, availability of similar plots to act as checks and disposition of the growers themselves gave greatest promise of final comparable results. Regard was also had as to the availability on or near the demonstration farms of machinery suited to the proper application of the sulfur dust. The sulfur itself was furnished without cost to the grower, who on his part, agreed to apply the material in such quantities and at such times as the entomologist in charge should direct.

It was the plan that the entomologist and the county agent should together visit each demonstration at weekly intervals to make counts of flea hoppers present, the number of blooms, to observe stage of growth and indication of flea hopper injury, on both treated and check plots, advise when intensity of infestation required the application of sulfur, fully inform all visitors to the demonstration as to its nature and progress and instruct them regarding the insect, and finally to supervise the picking of the cotton and to record the results. Mimeographed report forms were provided for entering all these and other important data, and we required that these reports be sent to our office covering each demonstration, as soon as the observations were made. Copies were required to be sent to Dr. Thomas of the experiment station as well to acquaint him with the progress of the work and to enable him to suggest any change of procedure his experience might indicate was desirable.

In conducting the work we were hampered by a season of abnormally frequent and heavy rains in the southern areas and by abnormally dry weather in the northern part, affecting in either case both the crop itself and the intensity of flea hopper infestation and in the southern sections delaying sulfur application beyond the time when needed and often even making it impossible to enter the fields for periodic observation. One county received 11 inches of rain in one night, while one field in another section stood for several days 12 feet under water. A number of demonstrations had to be abandoned because of the destruction of the crop. An early and especially virulent infection of the crop by the Texas cotton-root rot nullified the results, as measured by production, on several of the demonstrations.

We were pleased to note, however, the general attitude of the growers toward the method even though in some cases dependable production records could not be obtained. Without exception, the effect of sulfur application was noticeable in the decreased number of insects and the increased number of blossoms, so that the growers, as well as their neighbors, recognizing the abnormal conditions, plan on their own responsibility to make application of sulfur to their entire acreage another season.

The production records, as finally provided our office, should be of extreme interest to Texas cotton farmers. The highest increase in yield resulting from dusting as compared with yields on check plots was 442 pounds of lint cotton per acre while the lowest increase was 16 pounds per acre. The average increase in yield of all completed demonstrations was 151.58 pounds per acre. One grower with an increase in yield of 298 pounds of lint cotton per acre himself assigned $8 per acre as his net profit from dusting.

We have not been content to rest upon the mere accumulation of the season's data. We have felt that the acquisition of success in control under the adverse conditions that existed justified our carrying the results to the cotton growers of the state as a whole and acquainting them with the essentials of control. To facilitate this, we built four exhibition booths, all alike, with some features merely to fix interest and others to set forth the more technical details of control. These have been set up at as many of the fall fairs as was physically possible and are now being taken for three-day stands to such counties as express a desire for

them. The interest manifested in these exhibits has fully justified the trouble and expenditure contingent upon them. These booths have been exhibited at 21 places and have been viewed with interest by 131,600 people, or one out of every 40 of our Texas population.

Our procedure for 1937 has not been fully decided. At this time it is thought that two temporary assistants will be available for the extension of the program. Next season, however, instead of making the demonstration an individual enterprise, it is intended to offer it only where a group of growers manifest an interest in having it conducted on the farm of one of their number. Not so many demonstrations will be attempted as were carried out in 1936. Rather they will be kept to a minimum, the greater part of the assistant entomologist's time being reserved for meetings with groups of farmers in fields wherever demanded, acquainting them with the insect and its damage, aiding them to judge for themselves when sulfur application should be made and otherwise serving in such manner that the growers learn to handle a flea hopper infestation without close supervision by a technical advisor.—5-13-37.

SECTION OF PLANT QUARANTINE AND INSPECTION

The Alfalfa Snout Beetle

P. N. ANNAND, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

The alfalfa snout beetle, *Brachyrhinus ligustici* L., because of its potential importance as a pest of alfalfa and other crop plants, has been of much interest to the Bureau of Entomology and Plant Quarantine since its discovery in the state of New York. Although investigational work has been left largely to the state agencies, the Bureau has kept in contact with the work and has kept sufficiently informed on the distribution and abundance of this insect to offer a basis for judgment of its danger to other crop areas and its importance from a quarantine standpoint. E. W. Beck, of this Bureau, was stationed at Oswego, N. Y., during the active migration period of the beetle in 1934 and 1935, and assisted in making the early distribution surveys. Since 1935 contact with the work has been maintained through conferences with the state workers and through occasional visits to the infested area by representatives of the Bureau. The discussion of life history and control in New York to follow is based largely on information furnished by the state agencies.

Occurrence and distribution.—According to the literature *Brachyrhinus ligustici* is distributed practically throughout Europe. It is reported as being especially injurious in Germany, Austria, France and Hungary, and has for many years been recognized as an important pest in Europe.

In April 1933 H. L. Page, county agent of Oswego county, N. Y., submitted to the agricultural experiment station at Cornell University specimens of a beetle that he found migrating from alfalfa to raspberries, on which they were feeding. These beetles were identified by Cornell

entomologists as *Otiorhynchus ligustici*, an identification that was confirmed by L. L. Buchanan, of the Division of Insect Identification of the Bureau of Entomology and Plant Quarantine, who placed it under *Brachyrhinus*. G. W. Herrick (1933) reported this finding in June. The county agent was of the opinion that this insect had been in Oswego county for a considerable period, as severe injury to alfalfa similar to that caused by the snout beetle larvae had been prevalent for at least seven years but had been attributed to the first-year larvae of white grubs. Later L. L. Buchanan found a specimen of *B. ligustici* in the Wickham collection in the United States National Museum, labeled Oswego, N. Y., May 4, 1896. It is not known whether this insect has been present around Oswego continuously since that date, but it is likely that infestation sufficient to cause damage occurred there for many years previous to its discovery. Oswego receives a large volume of imported material owing to its location at the mouth of the Oswego river, which is a part of the New York barge canal system, and it is possible that the insect was originally introduced in commodities from Europe transported through this channel.

A preliminary survey made in Oswego county late in the fall of 1933, directed by the New York State College of Agriculture, indicated that the beetle was present in various parts of an area of 40 square miles around the city of Oswego.

During June, August and September 1934, E. W. Beck was assigned to Oswego by the Bureau of Entomology and Plant Quarantine to conduct a survey cooperatively with the New York State College of Agriculture. The scouting consisted of an intensive examination of the fields surrounding the originally discovered infestation. It was limited to Oswego and Jefferson counties. Diggings for larvae and search for adults and damaged plants were made with the idea of determining the limitations of the infestation and the possibility of conducting control or eradication measures. As a result of this survey, the insect was found to be established in both Oswego and Jefferson counties in a discontinuous narrow strip of land along the southern and eastern shores of Lake Ontario. It was found only in the townships of Oswego, Hannibal, Minetto and Scriba in Oswego county, and of Hounsfield and Ellisburg in Jefferson county.

In 1935 funds were obtained by the state for a more extended survey under the direction of A. B. Buchholz, director of the state bureau of plant industry. Mr. Beck, of the Bureau of Entomology and Plant Quarantine, assisted in training the crews and extending the intensive survey to outline the limitations of the local infested area, while the state crews covered a wider area.

A part of the area was surveyed in the spring, a part in the fall, and a part in both spring and fall. The spring survey consisted of examination of the alfalfa fields in an attempt to locate adult beetles during the migrating period, and of a limited amount of digging to reveal the presence of larvae. In certain cases short barriers of naphthalene were also erected in the fields and examined at intervals for migrating adults. Observations for migrating beetles were also made along natural barriers, such as ditches and roadsides. The fall survey consisted primarily

of examination of fields for wilted or injured plants and a subsequent examination of the roots of such plants for the occurrence of the grubs. As a result of this survey the city of Oswego, New Haven township, in Oswego county and Henderson township in Jefferson county were added to the infested area.

It is Mr. Beck's opinion, after the two seasons' experience in Oswego, that late summer and early fall are probably the best times for scouting, as a small number of grubs will cause injury to the alfalfa which can be detected readily at those times. Where the adult beetles occur in small numbers it is difficult to find them, as they remain hidden to a large extent and migration is dependent largely upon climatic conditions and is limited to the warmer periods of the day. Where the beetles are abundant, however, they can be readily detected migrating or feeding on the plants, and test barriers to accumulate migrants are useful when the barriers are examined occasionally to check on the occurrence of trapped adults.

In addition to the direct survey for the beetle, cruisings and scoutings were made in other parts of the state by the regular horticultural inspectors and, with the help of the county agents, alfalfa growers in all parts of the state were sent illustrated circulars on the alfalfa snout beetle, with the request that any suspected insects be submitted for authentic determination. No new areas were revealed by this scouting.

The known infested area is located entirely outside the New York alfalfa belt. Alfalfa is not grown in the infested area for other than domestic consumption, as the two counties are primarily dairy sections. Alfalfa is frequently seeded with timothy or pasture grasses, and poor stands of alfalfa are the rule rather than the exception.

Description.—The alfalfa snout beetle has been described and illustrated by Charles E. Palm (1935). No detailed description is necessary here. This bulletin also reviews the information available up to the time of its publication, in April 1935, on the life history and control of the insect under Oswego conditions.

Life history and habits.—The species is entirely parthenogenetic, no males having been found in the United States, although there is a doubtful report of one male having been found in Europe. It usually has a two-year life cycle, but under unfavorable conditions three years may be required.

In New York, according to Palm and Beck, the adults overwinter in the soil, at an average depth of about 1 foot, work their way upward during the first three weeks of April, and begin to emerge during the last week of April. In 1935, from April 21 through May, the adults migrated in tremendous numbers out of heavily infested plowed and unplowed alfalfa fields to surrounding fields, in search of favorable locations for oviposition. The primary migration stopped and oviposition began about June 1, continuing to some degree until the early part of August, although the peak of oviposition was reached well before this time. The adults feed on the foliage of various plants during the oviposition period. Secondary migrations may occur later in the season when stimulated by unsatisfactory food conditions or exposure to higher temperatures resulting from the cutting of the hay. The eggs are laid in the upper 2 inches of

soil and hatch in from two to nine days, depending on the temperature. The larvae immediately begin feeding on the roots of the nearest suitable plants and continue until interrupted by cold weather. They begin feeding again the following spring. Palm reports as many as 200 larvae in 1 cubic foot of soil from an infested alfalfa field. Investigations at the Cornell station indicate that the larvae may go as deep as 34 to 38 inches, and a depth of 16 to 18 inches is common.

Pupation begins in June and continues through the early part of July. It takes place in cells at different depths in the soil. The pupal period is approximately two weeks. The adults remain in the cells in the soil until the following spring, when they emerge to produce the spring brood and begin migration.

Although the species usually has a two-year life cycle, adults appear each year. This might be explained by separate introductions or by the delayed or accelerated emergence of certain individuals due to special food conditions or other factors, thus establishing a brood in the alternate year. The fact that this may not have occurred in the more recently infested areas emphasizes the desirability of scouting for larvae as well as for adults, and of examining suspected areas for two years in succession. Control would probably be much easier if only one brood of two years' duration had to be considered.

Host plants of economic importance.—Estimates of injury by this insect in Europe vary considerably. Some writers list it as a minor pest, while others indicate that it is sometimes a pest of economic importance. It has been reported as being especially injurious in vineyards and to fruit trees in Germany, and severe outbreaks are reported on hops in Bohemia. On grapes the adults eat the buds that are near the ground. The most extensive injury is reported to alfalfa, and many authors consider it to be the preferred host of the larvae. The host plants in Europe as enumerated by various authors include grapes, roses, plums, lettuce, peaches, hops, beans, turnips, asparagus, alfalfa, beets, privet, fruit trees, clover, strawberries, raspberries, hawthorn, sycamore and other other plants. The adult is apparently indiscriminate in its feeding habits, feeding on the leaves, buds and tender shoots of a great variety of herbaceous and woody plants. The adults probably do much less damage than the larvae, which confine their feeding to the roots.

In the United States Palm and Beck have made a preliminary study of the host plants of both adults and larvae. Palm (1935) lists as host plants of the adult, in the Oswego area, alfalfa, rhubarb, strawberry, raspberry, narrow-leaved dock and several species of weed seedlings. In the insectary the adults fed readily on tender shoots of asparagus, apples, sour cherry, wild cherry, currant, grape, red clover and yellow and white sweetclover. Economic damage in the Oswego area resulting from the feeding of adults on strawberry and raspberry foliage and on rhubarb, has been reported by Beck and Palm. This list of hosts has been further extended as a result of more recent observations by workers at the Cornell station.

The larvae were reported as feeding on the roots of alfalfa, red clover, alsike clover, narrow-leaved dock, broad-leaved dock, wild carrot, dandelion and yellow and white sweetclover; and in areas in alfalfa fields that

had been destroyed by the feeding larvae large numbers of the larvae began to feed on the roots of cinquefoil, goldenrod, aster, poverty grass, wild strawberry, sorrel, timothy, quack grass, orchard grass and other plants. It is not known, however, whether the larvae can mature on these supplementary plants.

The ability of the larvae to live on the roots of a number of the common weeds complicates control or eradication measures, as the larvae have been taken on the roots of such plants in uncultivated areas in proximity to infested alfalfa fields.

The larvae eat out deep grooves in the main roots and cut off the side roots, occasionally even severing the main tap root. Plants have been found on which the main root was cut off at a depth of only 2 inches. The main root may be grooved and gouged to a depth of 1½ to 2 feet. Beck reports that an examination of the alfalfa in two fields at Oswego which had been plowed up because the farmers believed that they were "running out" showed practically all the roots to be injured. In the most heavily infested field about half the alfalfa had been destroyed as a direct result of snout beetle injury. The injury usually starts in small patches, and as the plants die the larvae move to new hosts, thus constantly enlarging the dead areas.

Methods of control.—Observations on this pest in the Oswego area indicate that it may be one of the major pests of alfalfa, and its importance to the alfalfa and clover industry is such that precautions should be taken to prevent its further distribution and to reduce the infestation in the areas where the insect now occurs. The control work that has been done to date has been conducted entirely by the New York College of Agriculture, and the results must be considered as tentative because of the short period during which it has been in progress. The various methods tested include the use of barriers, poison sprays and dusts, and poison baits. The most promising so far developed is the use of a wheat shorts–raisin–sodium fluosilicate bait, especially when it is combined with plowing of the infested fields and thorough cultivation to remove any weeds on which the beetles might feed. The plowing and cultivation force beetles to move from the infested field and to feed on the poisoned bait. Palm (1935) reports that the effectiveness of this bait may be well over 90 per cent if the application is properly made and timed.

During the spring of 1936, the state of New York conducted an extensive control campaign with the use of this bait, under the direction of A. B. Buchholz of the state bureau of plant industry. The entire infested area was carefully mapped and all the known infested fields were treated. Although this method cannot be depended upon to eradicate the pest, it should result in a very material reduction in the intensity of the infestation, especially if it is repeated for two or three years and is extended to cover any new infested area that may be found. Baiting combined with plowing is more effective than baiting alone. The baiting during 1936 prevented general migration and practically eliminated the hazards of infestation of vehicles and crops in the path of the migration.

Danger of spread to other areas.—The small size of the area now infested, in view of the apparent long establishment of the beetle there, indicates that it spreads very slowly. Oswego and Jefferson counties,

however, are not counties from which there is extensive movement of agricultural produce. There are three small nurseries in the infested townships which produce perennials and raspberry and strawberry plants mostly for local trade. There are two nurseries in Oswego county which ship outside the state, one at Pulaski in Richland township and the other at Hastings in Hastings township. Both nurseries are 10 to 15 miles from the nearest known infested field. There are several small nurseries in Watertown, N. Y., considerably removed from infested territory, but these are only local dealers. Shipments of strawberries originate in the infested township of Scriba in Oswego county, and onions, celery and other vegetables are consigned from many of the towns in Oswego county near Oswego. These truck crops are grown on muck soil, which has not been found subject to infestation. Quantities of timothy hay are produced in Jefferson county, but most of it is for local use. Timothy hay is also shipped from the uninfested township of Schroeppel, Oswego county.

It would seem that the larvae might be readily transported in balled nursery stock and possibly in strawberry plants, but that there would be little danger of their transportation in other agricultural commodities. Some gravel for use in road building is moved from infested areas in Oswego. This might be a means of local distribution. Gravel pits in the infested area were heavily baited in 1936, and movement of gravel is restricted during the migration period.

The transportation of adults offers a different problem in view of their migratory habit. There is some possibility that they could be transported in the baskets or crates with strawberry fruits or in other small fruits picked during the adult period of the beetle, and that hay cut in infested fields might harbor adults and afford a means of transportation. The fact that the adults are unable to fly reduces the danger of chance transportation by automotive vehicles. Observations on the rate at which the beetles disperse by foot indicate that they are able to move at least 200 yards during a period of one to two weeks. This method of dissemination might account for considerable local spread and result in infestation of commodities at some distance from infested fields.

In view of the restricted distribution of this insect and the fact that no general shipment of agricultural produce likely to be infested occurs from the area, and considering the control activities being conducted by the state, it does not seem that quarantine action directed against this insect is essential at this time. Its importance as a potential pest should be recognized, however, and close observation maintained on its further distribution. As soon as it enters areas from which there is extensive shipment of agricultural produce likely to be infested, quarantine action should be considered as a measure to prevent further dissemination of this undoubtedly important crop pest.

Because of its present extremely limited distribution, the possibility of eradicating this pest has been suggested. No careful study of the situation has been made which can be used as a basis for evaluating the possibility of eradication. In such a study the potential importance of the pest should it gain entrance into important alfalfa areas should be considered in relation to the cost of such action under conditions occurring

in the area now infested. The fact that it is a subterranean insect and that it has a large number of hosts might well make an attempt at eradication extremely difficult or entirely impracticable.—7-9-37.

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Pathological Phases of Potato Wart Disease

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Potato wart, formerly regarded as a potato malady of primary rank, was first described and named *Chrysophlyctis endobiotica* by Schilberszky (1896). This first description was made from wart potato tubers grown in upper Austria. Since that time this disease has been reported from most of the important potato producing countries, but it is in many instances restricted to a small percentage of the total potato acreage.

Potato wart was discovered in the United States by Sanders (1919) in 1918, in gardens in one of the coal mining centers of Pennsylvania. It has since been found in a few other limited areas in Pennsylvania as well as in West Virginia and in western Maryland. Effective state quarantines and the use of wart-immune varieties have prevented the spread of wart to other localities in the United States.

Causal agent.—Percival (1910) and Curtis (1921) give a detailed account of the cytology and life history of the wart fungus. It was originally described as belonging to a new genus, *Chrysophlyctis*, from two Greek roots meaning "gold ball," but Percival transferred it to the genus *Synchytrium*, which classification has been adopted by most of the later investigators of this organism.

The main stages of the life cycle of *Synchytrium endobioticum* are zoospores, prosori, sporangia and sori. The zoospore enters a host cell where it forms a uninucleate prosorus from which it migrates through the outer membrane into the host cell. After repeated nuclear divisions a new membrane is formed about this entire protoplast. By segmentation of the protoplasm three to seven thin-walled sporangia are formed within this membrane, which constitute a sorus. Subsequent nuclear divisions give rise to zoospores. Ruptures of the soral envelope and host cell wall release many motile cells which may function as zoospores or as gametes. The zoospores may enter a host and begin a new cycle, or they may fuse in pairs to form a zygote and penetrate the host tissue in which they develop resting spores, that after a dormant period, germinate to produce zoospores.

Pathological anatomy.—The motile spores of *Synchytrium endobioticum*, according to Curtis (1921), enter the epidermal cells. Hypertrophy

of the invaded cell results if infection is caused by zoospores, and hypertrophy followed by hyperplasia, if infection is due to a zygote. In both of these cases cells adjacent to the invaded cells are stimulated. A single prosorus affects a small group of epidermal cells. The zygote-induced hyperplasia provides in nonresistant hosts meristematic tissue favorable for reinfection with resulting proliferations or wart formation.

In semiresistant potato varieties, according to Artschwager (1923), wart development remains superficial and slightly resembles scab pustules.

According to Percival (1910), the wart is a malformed branch system stimulated by the parasite to grow irregularly.

Factors influencing infection.—Weiss (Weiss, Orton & Hartman 1925) has presented a comprehensive account of his findings on the influence of soil reaction, moisture, and temperature on wart infection.

Soil Texture and Reaction.—Surveys in the United States have shown no correlation between soil type and prevalence of wart. Infection has been produced in peat, sand, loam and clay soils. Although the most favorable soil reaction ranges from neutral to slightly acid, wart may develop in soils having a pH from 3.9 to 8.5

Soil Moisture.—Resting and soral sporangia germinate in water which also is essential for the distribution of the motile cells. Germination is prevented unless soil saturation occurs at some time during the season. Constant saturation, however, exerts a depressing effect on infection. Intermittent flooding followed by drainage and aeration favors infection.

Soil Temperature.—Under field conditions wart infection was observed to occur at a mean temperature of about 21° C. In constant soil temperature tests, infection was found to be limited to the range 12 to 24°. Infection from germinating soral sporangia occurred from close to 0 to 30°. From these observations it is apparent that, other conditions being favorable, wart infection may occur under a wide range of soil temperatures, as well as soil types and reactions.

Hosts susceptible to wart.—Although potato is the principal wart host with respect to economic importance and pathological interest, wart infection has been observed on other solanaceous plants. Cotton (1916) reports wart infections on *Solanum nigrum* and *Solanum dulcamara* in pot experiments. Kunkel & Orton (1920) found that tomato became infected when grown in wart infested soil. Weiss (Weiss, Orton & Hartman 1925) reported that *Solanum Jamesii*, *S. commersonii* and *S. chacoense* contracted wart infection from naturally infested soil.

Persistence in the soil.—Schaffnit (1920) found that potatoes became infected with wart when planted in originally infested soil after it had been in sod for nine years. R. E. Hartman's observations (information by letter November 1936) indicate that in a wart-infested locality in Pennsylvania wart appeared in soil after cropping for 10 years with wart-immune potato varieties. Weiss (Weiss, Orton & Hartman 1925) points out that viable resting wart sporangia have been found 6 to 9 inches below the surface of the soil where they may persist in a resting condition possibly due to lack of oxygen. It is assumed that oxygen is one of the essential factors for germination.

Immunity.—Extensive wart infection tests with potato varieties car-

ried on in Europe and the United States have shown that many varieties are immune from this disease. In the United States, Weiss, Orton & Hartman (1923) found that important commercial varieties like Irish cobbler, Green mountain, Burbank, Spaulding rose and McCormick are wart immune. With the wide range of adaptability of these varieties it is possible for growers in wart-infested areas to use an immune variety suitable for such areas.

Inasmuch as wart immunity has been found to be heritable (Salaman & Lesley 1923), there are prospects for the production of other wart-immune potato varieties adapted to the important potato-growing regions.

Since immunity conveys the impression that a host does not contract infection or that if incipient lesions are formed the parasite is incapable of reproducing itself, no variety should be termed wart immune unless such conditions exist. In this connection it is noteworthy that Glynne (1934) found that potato varieties appearing to be wart immune in the field may develop a transitory form of infection under laboratory conditions. From such incipient infections Miss Glynne obtained summer sporangia with which she infected wart-susceptible varieties. To guard against soil infestation it obviously is essential that varieties subject merely to incipient infection or developing lesions harboring wart sporangia must not be considered wart immune.

Although potato wart remains a serious disease if susceptible varieties are planted in wart-infested soil, this potato malady is no longer regarded as one of the worst potato diseases because of the many available wart immune commercial potato varieties.

In potato breeding programs involving breeding for disease resistance new potato varieties found to be resistant to other potato diseases should also be tested for immunity from wart, so that this once dreaded potato malady will cease to be a limiting factor in potato production.—5-19-37.

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EASTERN BRANCH

PAPER-READING SESSION, EIGHTH ANNUAL MEETING
New York, N. Y., November 1936

Occurrence of *L*-Nornicotine in *Nicotiana sylvestris*

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In 1931 the author (1931) pointed out that Pictet and coworkers (1901, 1906) had not definitely identified any of the secondary alkaloids accompanying nicotine in tobacco. Later Ehrenstein (1931) came to the same conclusion in criticizing the results of Pictet, but reported the presence of nornicotine and anabasine (neonicotine) as two of the secondary alkaloids of tobacco. Späth and coworkers (1935) also prepared nornicotine from tobacco, obtaining it in the pure levo form by suitable purification. Proof of the presence of anabasine in tobacco still rests on the results of Ehrenstein. The constants he obtained are not in strict agreement with those of pure anabasine, but sufficiently so to make it reasonably certain that he did isolate this alkaloid. Discovery by the author (1935) of anabasine in *Nicotiana glauca* also tends to substantiate its occurrence in tobacco.

Chemically pure nornicotine was first prepared by Von Braun (Späth, Hicks and Zajic 1936) by the demethylation of nicotine. His product, however, was partially racemized, giving (α) $-5.5°$. Ehrenstein's nornicotine from tobacco gave $(\alpha)_D - 17.7°$, while Späth, Hicks and Zajic (1935) obtained from tobacco a material with $(\alpha)_D^{20} - 40°$, from which he prepared pure *l*-nornicotine with $(\alpha)^{23} - 88.8°$. These investigators later (1936) obtained a nearly pure *d*-nornicotine from *Duboisia hopwoodii* with $(\alpha)_D^{20} + 86.3°$.

The author has studied the alkaloids of *Nicotiana sylvestris* as obtained from plants grown by H. H. Smith under the direction of W. W. Garner, chief of the Division of Tobacco Investigations and Plant Nutrition, Bureau of Plant Industry. The alkaloids were found to be *l*-nornicotine and *l*-nicotine. In composite material from leaves and stems of plants that had been used chiefly for seed production with some that had been topped and suckered, the total alkaloidal content was approximately 1 per cent. *L*-Nornicotine represented about 95 per cent of the total alkaloids and *l*-nicotine about 5 per cent. Anabasine could not be detected in the small quantity of alkaloids available.

While the percentage of nornicotine and anabasine in tobacco has not been stated definitely by any of the above-mentioned workers, it is safe to say that the toxicity to insects obtained with commercial nicotine can be attributed to the nicotine because of the small proportions of the secondary alkaloids.

Nornicotine has been recently tested as an insecticide against *Aphis rumicis* L. by Richardson and coworkers (1936). This nornicotine was prepared synthetically by Craig (1933) and represented the racemic

form. In view of results that have been reported showing that the levo form of nicotine is more toxic than the dextro form it may be found that *l*-nornicotine is also more toxic than the *d* or *dl*-nornicotine.

The author expects to report shortly on a method of separating nicotine, anabasine and nornicotine from each other, which will enable one to get a close approximation to the percentage composition of such mixtures as they may be found in varieties of *Nicotiana tabacum* and other species of *Nicotiana*.

Extraction.—The alkaloids were obtained from air-dried leaves by successive extractions with boiling water, each fraction being removed by decantation. The last extraction was a process of steaming for a short period to insure a more thorough exhaustion. The extracted fractions were combined and evaporated to a small volume on the steam bath, permitted to cool, and filtered from insoluble material such as bits of leaves, calcium citrate, calcium oxalate, etc. The filtrate and washings were combined and evaporated to a small volume, made strongly alkaline, and the organic bases extracted with ether in several portions. The ether extracts were combined, evaporated to a convenient volume (about 50 cc.), and the alkaloids removed by several successive treatments with dilute hydrochloric acid. The acid washings were combined and evaporated to about 20 cc., made alkaline, and the alkaloids extracted with ether in several portions. The ether extracts were combined, dried with solid caustic soda, and then evaporated to remove the ether, leaving an oil which was distilled under reduced pressure. From 335 grams of leaves about 3.2 grams of oil was obtained before distillation.

Separation of nornicotine from nicotine.—To remove the nicotine from the nornicotine, about 125 cc. of water was added to the oil, and the mixture was slowly distilled through a 30-cm. fractionating column until about 15 to 20 cc. remained in the flask. The course of the distillation was followed by titrating the distillate in parts as it was collected, alizarine sulfonic acid being used as indicator. To the residue in the flask about 60 cc. of water was added and distillation through the column repeated. These operations removed nearly all the nicotine and some nornicotine. The combined distillates were made slightly alkaline to phenolphthalein and redistilled through the column, as before, in two successive distillations. The titration of the distillate gave an estimate of the quantity of nicotine. It was found to be about 5 per cent of the total oil distilled.

To obtain material for proving the identity of the nicotine and determining its optical behavior, the combined and titrated distillate was evaporated to a small volume, made strongly alkaline and distilled through the column until 20 cc. was obtained. The solution had an optical rotation of $-3.3°$ V and a nicotine concentration of .755 per cent; theory $-3.4°$ V. The nicotine was next converted into the picrate, which melted at 224° C (cor.). As its melting point was unchanged by admixture with known picrate, it was evidently pure. The residues of nornicotine remaining in the distilling flasks were combined, water was added and distillation through the column repeated to remove a possible small quantity of nicotine together with a negligible quantity of the nornicotine. The residue in the flask was made strongly alkaline, extracted with

ether and the ethereal solution dried and then evaporated to an oily residue. The optical rotation of the residue was −49.5° V in a 2-cm. tube, giving $(\alpha)^{20}_{D}$ −80.0° circ. (sp. gr. 1.07). A higher rotation might have been obtained if this residue had been carefully distilled to remove every trace of water, but it was polarized directly to conserve the material for further work.

Tests for purity.—Proof of the purity of the nornicotine was obtained by examination of the picrate as obtained from 2 grams of alkaloidal material by the addition of alcoholic picric acid. Essentially all the alkaloidal material was precipitated in a crystalline form. The picrate, when filtered off and recrystallized from cold water after complete solution in boiling water, melted at 189–191° C (cor.), and on a second recrystallization melted at 191–192° C. Another sample of nornicotine was found to boil at 270–271° C at atmospheric pressure, apparently with some decomposition, which may have been due to impurities. The results agree with the constants given for nornicotine.

To obtain further proof of the identity of the nornicotine, a sample of nornicotine was prepared by the oxidation of nicotine with potassium permanganate solution cooled to 0° C according to the method suggested by Späth, Marion and Zajic (1936). With some difficulty a satisfactory picrate was prepared, which melted at the proper temperature, and the melting point was unchanged after addition of nornicotine picrate prepared from *Nicotiana sylvestris*.

A more satisfactory proof was furnished by converting the nornicotine into nicotine by methylation with formaldehyde and formic acid, by the method of Späth, Hicks and Zajic (1936). The nicotine was separated by distillation through the fractionating column and converted into the picrate. The picrate was once recrystallized and melted at 224° C, the melting point being unchanged upon admixture with known nicotine picrate.

Absence of anabasine.—Anabasine is known to be converted completely into its nitroso derivative when treated with nitrous acid under the proper conditions. The nitroso-anabasine is an insoluble oil readily extracted by ether. The nicotine-free alkaloid or alkaloids of *Nicotiana sylvestris*, when slightly acidified to litmus with hydrochloric acid and treated with sodium nitrite, gave no insoluble oily compound, although ether extracted some material that could be readily removed by washing with a little water. The results probably indicate the absence of any appreciable quantity of anabasine.—7-13-37.

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COTTON STATES BRANCH

PAPER-READING SESSION, TWELFTH ANNUAL MEETING
San Antonio, Tex., February 1937

Relative Importance and Seasonal Activity of *Cochliomyia americana* C. & P.

And Other Wound-infesting Blowflies, Valdosta, Ga., 1935–1936

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A knowledge of the relative importance of *Cochliomyia americana* C. & P., *C. macellaria* F., and the various species of *Phormia*, *Lucilia*, *Sarcophaga* and possibly other genera as primary invaders in the wounds of animals is of value in placing proper emphasis on the control of those species of greatest economic importance. Biological studies have indicated that *C. americana* is most often the primary invader in wounds of animals, but that under certain conditions the other species, which are normally necrobiotic in habit, may also be the first to invade wounds of animals.

A review of the literature indicates that comparatively little has been published concerning the relative importance of *Cochliomyia americana* and other related myiasis-producing Diptera. Available information dealing with the primary screwworm, *C. americana*, other than the original description by Cushing & Patton (1933), is found in the works of Brennan (1937), Bruce & Sheely (1936), Dove & Bishopp (1935), Dove & Parman (1936), King & Bradley (1935), Knipling & Tate (1935), Knipling & Rainwater (1937), Laake (1935, 1936), Laake, Cushing & Parish (1936), McGovran & Ellisor (1936), Parish & Laake (1935), Robinson (1935) and Tate (1935).

The primary object of the studies reported in this paper was to gain more information on the relative importance of the various species of wound-invading blowfly larvae in the wounds of animals. The incidence of the species as determined by the number of infestations, as well as

observations on the degree and type of injury in experimentally wounded animals, was used as a criterion of their importance. Data were also obtained, however, on the attractiveness of various types of wounds and of wounds of different ages; the host preferences, and the seasonal and daily activity of the flies in relation to air temperatures, and other pertinent points which will be discussed in this paper.

Materials and methods.—Studies were conducted in the vicinity of Valdosta, Ga., from September 23, 1935, to December 15, 1936. Grade sheep with long fleece, mixed breeds of short-haired goats, and a few calves, obtained locally, were used as experimental animals.

The experimental animals were artificially wounded and were released in a pasture so that they might be exposed to conditions as nearly natural as possible. Cuts approximately 3 inches in length and deep enough barely to slash the muscular tissue beneath the skin were made with an ordinary pocket knife or a scalpel in the various locations on the animals. With the exception of one series of sheep and goats, in which two wounds were made, each animal was given three wounds. One wound was on the rump and one on each shoulder. The hair or wool on an area 6 to 8 inches in diameter was closely clipped on the rump and on one shoulder, and the wound was made in the center of the clipped area. The wounds in the clipped areas were intended to simulate severe shear cuts.

Five sheep and five goats, with a few exceptions, were wounded and exposed in each series. In three series wounded calves were also included. New animals were wounded at about two-week intervals during the course of the experiments so that there would be a continuous exposure of wounded animals.

The wounds were examined and the eggs of *Cochliomyia americana* were removed once or twice each day during the active fly season, until the wounds healed. The eggs of other flies[1] were allowed to remain on the animal undisturbed, and the larvae were given opportunity to develop in the wounds naturally. By removing eggs of the primary screwworm before the larvae became established in the wounds, the experiments simulated conditions in a region uninfested with *C. americana*. The first larval infestations resulting under such conditions were considered initial or primary infestations by the particular secondary species involved.

In these studies, when there was some doubt as to the identity of the eggs they were removed and incubated. If the resulting larvae proved to

[1] The eggs of *Cochliomyia americana* are readily distinguished from those of *C. macellaria* and *Lucilia* spp. The eggs of the primary screwworm fly are whitish and generally are deposited in oval, shinglelike masses on or near the edges of the wounds, but frequently are deposited on the scab or dried tissues in the wound itself. In a few instances, however, eggs were deposited on moist surfaces. Occasionally the eggs are deposited in masses attached to the wool near the wound. In such cases the egg masses do not always have the characteristic flat shinglelike arrangement, but may be arranged in the more rounded mass somewhat characteristic of the egg masses of *C. macellaria* and *Lucilia* spp. In all cases, however, the eggs are arranged in more compact masses and are more firmly cemented together than are the eggs of secondary species. The eggs of *C. macellaria* and *Lucilia* spp. are slightly yellowish and usually are deposited among the wool or hair, loosely cemented together in irregular masses. The adults of *C. macellaria*, and to some extent those of *Lucilia* spp., have a tendency to group their eggs into large composite masses, numerous flies ovipositing in the same location near an attractive wound forming a clump that may contain many thousands of eggs.

The whitish eggs of *Phormia* spp. have a close resemblance to those of *Cochliomyia americana*. Although the eggs generally are deposited among the wool or hair, they may sometimes be found in or near the edges of the wound, and in such cases the eggs as arranged sometimes show a striking resemblance to the egg masses of *C. americana*.

be those of one of the secondary species, they were replaced in the wounds from which they had been collected.

Larvae of secondary species developing in wounds of the animals were determined by gross examination and checked by examining representative samples with a hand lens.

Results with the primary screwworm, *Cochliomyia americana*. ATTRACTIVENESS OF VARIOUS TYPES OF WOUNDS.—The total and average number of egg masses of *Cochliomyia americana* on the different types of wounds in sheep and goats are presented in table 1. The results show a marked preference by the flies for wounds on the shoulder of goats, and

Table 1.—Number of egg masses of *Cochliomyia americana* deposited on the wounds of sheep and goats, Valdosta, Ga., Sept. 23, 1935 to Dec. 15, 1936.

Type	Wounds Exposed Location	Number	Total No. Egg Masses for Each Type of Wound	Av. No. Egg Masses for Each Type of Wound
		Sheep		
Unclipped	Shoulder	130	71	.55
Clipped	Shoulder	125	284	2.27
Clipped	Rump	130	135	1.04
		Goats		
Unclipped	Shoulder	120	179	1.49
Clipped	Shoulder	115	171	1.49
Clipped	Rump	120	81	.67

on the clipped shoulder wounds on sheep as compared to similar wounds on the rump. In two series in which calves were exposed, a total of 78 egg masses were collected on the two shoulder wounds, and only one egg mass on the rump wounds. These data on calves support the results obtained for the two types of wounds on sheep and goats.

Wounds on the rump generally dry faster than similar wounds on the shoulder, which possibly explains in part why rump wounds are apparently less attractive.

The unclipped shoulder wounds on long-fleeced sheep showed the least attractiveness to the primary screwworm fly. This is possibly due to the difficulty encountered by the fly in getting to the wound and locating a suitable place to oviposit. The unclipped shoulder wounds on goats and calves where the hair was naturally short were equally or more attractive than the clipped shoulder wounds.

RELATION BETWEEN AGE OF WOUNDS AND THEIR ATTRACTIVENESS TO *Cochliomyia americana*.—The average number of egg masses of *C. americana* per wound collected from the wounded animals in relation to the age of the wounds is plotted in fig. 1. The data are based on the average number of egg masses per wound per day on the animals during the active season of the primary screwworms and when daily maximum air temperatures ranged above 70° F.

No doubt there are many factors that may cause variable results. The trend of the curves indicates, for these types of wounds, a rather prolonged period of attractiveness to *C. americana*. The fluctuations as recorded in the graph were probably largely due to climatic factors, or

fly abundance, or perhaps to some inherent properties of the wound itself. The height of attractiveness of these types of wounds appears to be on about the fifth to the seventh day. Apparently fresh, bleeding wounds are not necessarily the most attractive type of wounds for the

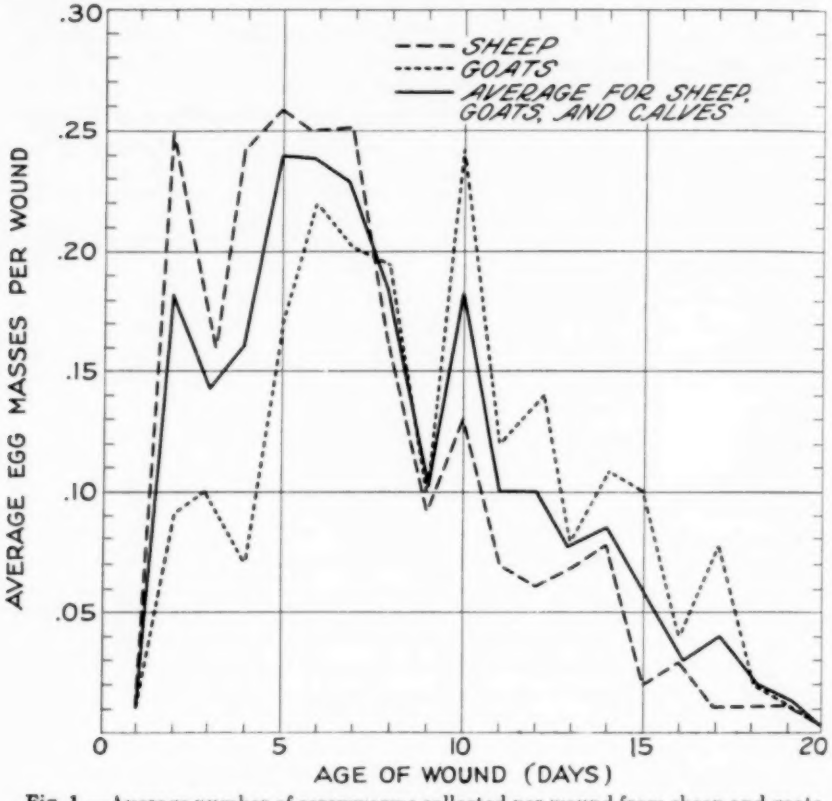

Fig. 1.—Average number of screwworms collected per wound from sheep and goats, in relation to age of wounds. Daily maximum air temperatures ranged above 70° F.

primary screwworm. Wounds during the first day of exposure (one to approximately eight hours old) appear to be relatively unattractive.

ACTIVITIES OF *Cochliomyia americana* IN RELATION TO AIR TEMPERATURES.—Using the number of egg masses collected on the wounded animals as a criterion, *C. americana* appears to be as active on days when maximum temperatures are approximately 75° F as on days when temperatures range above 80°. Air temperatures below 70° in general show a marked decrease in activity as compared with the activity when daily maximum temperatures range above 70° F. The lowest maximum temperature when oviposition was noted to occur in nature was 63.5° F. Oviposition on one occasion occurred in the field on a 100 per cent cloudy day when the maximum air temperature recorded was 64° F.

Data indicate that on the first warm day after temperatures have ranged below that required for normal activity more egg masses are deposited than the average for several days in succession of similar temperature ranges.

A minimum temperature of 24° F apparently had little effect on adults of *Cochliomyia americana* in nature. When the maximum temperature was 76° F on the second day after a night when the temperature had dropped to 24°, the number of egg masses collected on wounded animals was comparable to the number collected on days previous to the cold

Table 2.—Primary infestations by larvae of secondary species of blowflies in wounds of sheep, goats and calves, Valdosta, Ga., September 23, 1935, to December 15, 1936.

Type and Location of Wounds Exposed	No. Wounds	No. Infestations	Number of Wounds Infested by					
			Cochliomyia macellaria	*C. macellaria* and *Lucilia*	*Lucilia*	*Phormia*	*Phormia* and *C. macellaria*	*Sarcophaga*
			Sheep					
Unclipped shoulder	130	34	18	2	8	4	0	2
Clipped shoulder	125	32	6	0	7	11	1	7
Clipped rump	130	16	3	2	3	1	0	7
			Goats					
Unclipped shoulder	120	5	0	0	0	2	0	3
Clipped shoulder	115	4	1	0	2	0	0	1
Clipped rump	120	5	2	0	0	0	0	3
			Calves					
Unclipped shoulder	14	2	0	0	0	2	0	0
Clipped shoulder	14	0	0	0	0	0	0	0
Clipped rump	14	0	0	0	0	0	0	0

spell. Continued cold (minimum 20–47°, maximum 33–65° F) over the period December 11–28, 1935, apparently killed most if not all of the adults in nature, for no egg masses were collected on wounded animals during a following warm period (December 29 to January 14) when maximum temperatures were favorable for screwworm activity.

Results with the secondary species. Species Involved.—*Cochliomyia macellaria*, *Phormia* spp., *Lucilia* spp. and *Sarcophaga* spp. were the only flies in addition to *C. americana* encountered as primary invaders in wounds of the animals exposed in these series. No specific determinations were made of the larvae in the experimental animals, with the exception of those of *C. macellaria*. From another series of experiments conducted at Valdosta, Ga., however, the following species have been bred from the wounds of animals: *Cochliomyia macellaria* F., *Phormia* spp., *Lucillia sericata* Meig., *L. caeruleiviridis* Macq., *L. cluvia* Walk., *L. cuprina* Wied., *Sarcophaga bullata* Park., *S. marionella* Ald., *Cynomyia cadaverina* Desv., *Calliphora* spp., *Musca domestica* L. and *Hermetia* spp.

Host Susceptibility.—In table 2 are presented data on the number and type of wounds in which the various secondary flies initiated infestations on sheep, goats and calves. Sheep, in these experiments were more often infested by the secondary species than were the goats or calves.

Reinfestations of wounds of goats initially infested with secondary species were uncommon, whereas approximately one-half the wounds on sheep were reinfested after the initial infestation. No severe infestations

by secondary species occurred in goats or calves, whereas 14 of the sheep died as a result of infestations by secondary species.

When once infested with larvae of the primary screwworm fly, all of the experimental animals (nine sheep and 13 goats) that were not treated eventually died as the result of frequent reinfestations by *Cochliomyia americana* and the invasion of such infested wounds by secondary species.

ATTRACTIVENESS OF VARIOUS TYPES OF WOUNDS.—In table 2 are presented data showing the number and type of wounds on sheep, goats, and calves initially infested by secondary species. No significant difference in attractiveness to secondary species of the various types of wounds on goats was noted, although the number of wounds infested was small. Also, since only two infestations were initiated by secondary species in 42 wounds on calves, no conclusions can be drawn as to the type of wound most attractive.

The shoulder wounds on sheep, however, appeared to be more attractive to secondary species as a group than were the rump wounds. The unclipped shoulder wound was slightly preferred to the clipped shoulder wound.

The data show specific preference on the part of certain secondary species to the different types of wounds. *Cochliomyia macellaria* was more often encountered in the unclipped shoulder wound, whereas *Phormia* was more often found in the clipped shoulder wound. The unclipped shoulder wounds as compared with the clipped shoulder and rump wounds were comparatively unattractive to *Sarcophaga* spp.

TYPE OF INJURY PRODUCED BY LARVAE OF SECONDARY SPECIES.—The effect of secondary species of larvae on the wounds varies. With light infestations there was an improvement in the condition of the wounds. It is only when the larvae are present in large numbers either in the wound or in the area around it that injury is apparent.

The larvae of *Cochliomyia macellaria*, *Lucilia* spp. and *Phormia* spp. had a tendency to feed outside of the wound in the wool when infestations started in the unclipped shoulder wounds of the long-fleeced sheep. Infestations in the clipped wounds were generally restricted to the wound itself. Some destruction of tissues was apparent, especially when infested with *Phormia* spp., and in certain cases at least a bloody discharge was produced in wounds infested with *Phormia* which was not unlike that produced by *C. americana*.

Although the number of initial infestations in the unclipped shoulder wounds was only slightly greater than in the clipped shoulder wounds, the injury caused by the infestations in the former was much more severe. Fourteen of the 130 sheep exposed in these experiments died as the result of infestations in the unclipped shoulder wound, whereas none died from infestations in the clipped shoulder or rump wounds.

The presence of long wool immediately surrounding the wound apparently affords better conditions for development and spread of larvae than when the wool is clipped from the region of the wound. In severe infestations the larvae feeding outside of the wound in the wool make small perforations in the skin, giving it a "honeycombed appearance." A dark-colored discharge is present, although there is generally no evidence of bleeding. Developing larvae sometimes show a reddish color in

the foregut which is apparent through the integument. No tests for blood were made on such larvae.

Animals severely infested usually harbored several species of secondary larvae. Ten of the 14 sheep that died were apparently killed by *Cochliomyia macellaria*, three were apparently killed by *Phormia* spp., and one by *Lucilia* spp., although in each case all three species were represented in the infestation by the time death occurred.

Larvae of *Sarcophaga* spp. were always found feeding in the wounds, but no harmful effects on the animals were noted as a result of their presence. In some cases at least there appeared to be an improvement in the condition of the wound as a result of such infestations.

SEASONAL ACTIVITY.—On the basis of observations made during the present studies it may be stated that the activities of the various secondary species vary at different times of the year. Infestations of *Cochliomyia macellaria* predominated from August to October, inclusive, those of *Phormia* spp. predominated from November to March, and those of *Lucilia* spp. from April to July.

Discussion.—In an attempt to evaluate the relative importance of the primary screwworm, *Cochliomyia americana*, as compared with the other wound-invading blowflies or secondary species, it is necessary to consider the association of these two types of myiasis-producing Diptera and to consider the type of host. It is known from field as well as from experimental observations that wounds of animals infested with the primary screwworm become more attractive to secondary species of blowflies as well as to the primary screwworm. Severe infestations, in animals under southeastern conditions frequently if not always result in an invasion of the wound with numerous larvae of secondary species. This invasion of infested wounds by secondary species, observations show, occurs sooner in sheep than in short-haired goats. These secondary species are no doubt of considerable economic importance in that they may cause or hasten the death of animals previously infested with the primary screwworm.

In areas in the United States where *Cochliomyia americana* is not present there is in general comparatively little death loss from wound myiasis in domestic animals, even though the more common and the more important of the secondary species may be present in such areas.

The results of the studies during 1935 and 1936 on the relative importance of the two types of myiasis-producing Diptera, as far as sheep, short-haired goats, and calves are concerned, tend to confirm general observations that losses from myiasis are not great when the primary screwworm is controlled. Exceptions to this generalization are in wounds of sheep with long fleece when such wounds are in regions surrounded by long wool. It is questionable, however, whether such wounds often occur under natural conditions on sheep with long wool.

The studies reported in the foregoing pages dealt entirely with myiasis in wounds of experimental animals. Bishopp & Laake (1915) have shown, however, that under certain conditions sheep are susceptible to severe wool maggot infestations by *Phormia* spp., *Lucilia* spp. and possibly other forms which are attracted by soiled wool or other conditions not necessarily associated with a wound. *Cochliomyia macellaria* is known

to be involved sometimes in cases of this kind. It is also well known that dehorning wounds in cattle are often susceptible to severe infestations of larvae of secondary blowflies, primarily *Phormia* spp.

Summary.—The primary screwworm fly, *Cochliomyia americana*, is the most important species causing wound myiasis of animals in the vicinity of Valdosta, Ga. Wounds around which the wool had been clipped on the shoulders of sheep were the most attractive to the primary screwworm fly, and unclipped shoulder wounds of goats were second in attractiveness. Unclipped shoulder wounds of sheep were the least attractive, but this type of wound was the most attractive to the secondary blowfly *C. macellaria*.

In the types of wounds studied, the height of attractiveness for *Cochliomyia americana* is reached on about the fifth to the seventh day.

Cochliomyia americana appeared to be as active on days when the maximum air temperature reached 75° F as on days when the temperature was 80°. Activity is greatly decreased when air temperatures fall below 70°. A minimum temperature of 24° apparently did not kill adults in nature.

Cochliomyia macellaria, *Phormia* spp., *Lucilia* spp. and *Sarcophaga* spp. were the only secondary flies found to initiate infestations of wounds.

Sheep were more susceptible to infestations by secondary blowflies than were goats or calves.

A study of the seasonal activity of the various species of secondary blowflies showed that *Cochliomyia macellaria* caused more infestations during the period from August to October, whereas *Phormia* spp. predominated from November to March, and *Lucilia* spp. from April to July.—4-10-37.

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Myiasis in Wild Animals in Southwestern Texas

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Since the discovery (Cushing & Patton, 1933) that *Cochliomyia americana* C. & P. is the important primary screwworm of the new world, the relation between its breeding in wild animal life and the control of the species in domestic animals has become much more significant. Fly-trapping records in southwestern Texas and other sources of information indicate that the adult population of *C. americana* is greater than would normally be expected from infestations in domestic animals alone, especially in view of the fact that the ranchmen spend a large portion of their time destroying the larvae in the wounds of livestock.

The suggestion has been made that wild animals serving as hosts of *Cochliomyia americana* must be a constant source or reservoir of screwworm infestation for domestic animals, and aside from its being one of the worst problems with which ranchmen must contend, this pest is a factor in game conservation, because it takes a yearly toll of game animals.

The investigations presented in this paper were conducted for the purpose of determining the species of flies responsible for myiasis in wild animals, the kinds of animals infested, the character and predisposing causes of the wounds, the incidence of cases, and the possible means of control. Notwithstanding the fact that myiasis appears to be fairly common in wild animals, authentic records are very difficult to obtain. It is not easy to observe wild animals closely in nature; many are nocturnal and are infrequently seen; early infestations in small animals are not readily discernible, and in the later stages of infestation, before death occurs, the animals seek hiding places or, if in the open, their carcasses are quickly destroyed by vultures or carnivorous animals; and infestations at any given time may not exceed 2 to 3 per cent of the total number of animals in an area.

Some of the data herein reported were obtained in 1934, but not until 1936 was any determined effort made to collect actual specimens.

[1] Acknowledgment is made of the interest and helpful suggestions of D. C. Parman, under whose general direction this work was done.

Myiasis in Texas cottontail.—In May, June and July 1936 an examination of 298 Texas cottontail rabbits, *Sylvilagus floridanus chapmani* Allen, taken in nature showed that 12, or 4 per cent, were infested with the larvae of *Cochliomyia americana;* 1, or .34 per cent, with *C. macellaria;* and 61, or 20.5 per cent, were or had been infested with rabbit bots. One additional animal that was found dead was infested with third-instar larvae of *C. americana.* These animals did not exhibit evidence of injury from the screwworm infestations before they were captured, which indicates that they are quite resistant to the effects of these parasites. It is practically certain, however, in view of the tendency of the fly to reinfest wounds, that the infestations in most cases would have increased and continued until the animals died. The majority of the screwworm larvae collected from these animals were in the third instar, although in certain cases a large number of first and second-instar larvae were present. The growth of the first-instar larvae always terminated when the animal died. In some of the cases the maggots had completed their development and were dropping from the wound when the animal was taken, whereas in others the infestations were comparatively fresh.

With one exception, that of a gunshot wound, the infestations were due to injuries inflicted by larvae of the rabbit botfly, *Cuterebra buccata* F. The bot larvae open holes in the skin; and these wounds, which often do not heal for six or eight weeks, offer favorable sites for the oviposition of screwworm flies. Of the 72 bot larvae collected, 39 per cent were encysted underneath, between the hind legs, 35 per cent on the abdomen and sides, and the rest were found on the backs, shoulders, rumps and thighs.

The size of the wounds caused by the screwworms ranged from one-half to 1 inch in diameter, and the number in the wound ranged from four to 150 of the third instar and from 150 to 250 of the first and second instars.

These data indicate that at least 300 larvae of *Cochliomyia americana* can develop in a cottontail rabbit, and in view of the large number of these animals in southwestern Texas it is believed that they contribute materially to the maintenance of the screwworm fly population in this area.

Myiasis in the Texas jack rabbit.—Of the 16 cases of myiasis observed in the Texas jack rabbit, *Lepus californicus texianus* Waterhouse, three were found in May, three in June, three in July, one in August and two in September 1936; and four animals were found dead although it was evident that they had died as a result of the infestation. No larvae of *Cochliomyia americana* were found in two cases, one of which produced larvae of *Lucilia* sp., *Sarcophaga* sp. and *Synthesiomyia* sp.; the other, only larvae of *Sarcophaga plinthopyga* Wied. These secondary species were also present in several of the other 14 cases in association with larvae of *C. americana.* Some of the cases showed evidence that third-instar larvae had left the wound prior to the date on which the animals were obtained. Many of the wounds also contained eggs of *C. americana.*

Boils, or some disease which caused the skin to break, and accidental injuries were the predisposing causes of infestations in eight of the cases examined. Predators such as dogs, coyotes and hawks often inflict wounds which become infested with fly maggots. Two of the cases

examined were caused by either dog or coyote bites. Gunshot wounds are frequent inciting causes of screwworm infestations in rabbits, especially in the vicinity of towns and villages where there is considerable hunting. Five of the infestations of the 16 examined were due to this cause. Roberts (1931, 1933) reported *Cochliomyia macellaria* in jack rabbits following gunshot wounds and bot injury.

Of special interest is the number of *Cochliomyia americana* larvae that a jack rabbit (average weight about 6 pounds) can bring to maturity. In one instance, 570 flies emerged from the collection of third-instar larvae, and it was estimated that at least 1000 larvae were in the wound

Fig 1.—Screwworm case in opossum. Wound probably caused by ticks.

at the time the animal was taken. The rabbit was strong and active despite this heavy infestation. The jack rabbit, being about three times heavier than the cottontail, can support more larvae, and it is not unusual to find cases in which wounds are infested with 300 to 500 larvae of *C. americana*.

The number and age of the larvae in the wounds examined ranged from about 50 third-instar only to 1000 of all instars. The wounds were 1 to 3 inches in diameter. Infestations occurred more commonly on the hams and between the rear legs, but the shoulders, neck and front legs were also infested.

Of 205 jack rabbits killed in May, June and July 1936, seven, or 3.4 per cent, had screwworm cases. The jack rabbit is one of the most common animals in southwestern Texas, and the data suggest that this species is an important source of infestation by *Cochliomyia americana*.

Myiasis of the Texas opossum.—Opossums are nocturnal, hiding during the daytime in hollow logs, trees and brush piles, where they are readily accessible to screwworm fly attack. The males fight considerably during the breeding season, with resulting wounds that are ideal for fly oviposition, fig. 1. One authentic record and two or three others which are practically authentic show that when the female opossum is carrying the

young in the pouch, this part of the body is an attractive place for oviposition by screwworm flies, even though the skin is not broken.

Fighting, carrying young in the pouch, and ticks probably are the most important causes of the wounds that later become infested. Observations on experimental animals indicate that the Texas opossum, *Didelphis mesamericana texensis* Allen, is very susceptible to oviposition by *Cochliomyia americana*. Of 10 opossums caught in May, four had natural infestations of *C. americana*. Most of the larvae in these cases were in the first instar. One wound contained about 100 second-instar larvae. Approximately 400 first-instar larvae was the maximum number found in a wound.

Fig. 2.—Deer that died from screwworm infestation on back of head.

People have reported having observed opossums with large infestations and in a crazed condition wandering about in daylight. Although opossums are not frequently observed, it is indicated from the number of furs sold yearly (about 800,000 in Texas) that the species number into thousands in each locality, and a small percentage of infestation would yield a considerable number of flies.

Myiasis of the white-tailed deer.—Although the writer observed only four cases of myiasis in deer in 1936, more than 80 reports from ranch people and others indicate that the white-tailed deer, *Odocoileus virginianus texanus* Mearns, is frequently infested with screwworms, and that hundreds succumb annually, especially in Kerr, Mason, Real, Gillespie and Uvalde counties.

Although deer exhibit considerable sagacity in licking out the larvae and standing in water to drown out the maggots, they are instrumental in rearing to maturity thousands of larvae and eventually die, fig. 2. In each of two cases observed, about 3000 larvae of *Cochliomyia americana* in all stages of development were present in the wound.

Fawns, does and bucks are all subject to infestations. Fawns at birth are susceptible in the navels, and later in wire cuts on various parts of

the body. Does become infested in the vulva at fawning time, and also in wire cuts. One ranchman on a 2000-acre ranch in Kerr county saw six does nearly dead with severe vulva infestations on his ranch in 1935. When bucks are "in velvet" (*i.e.*, when old horns are shed and new ones are developing) this area is especially tender and easily injured when they are going through heavy brush and fences. The increasing amount of brush and extent of wire fencing during the last 50 years is probably augmenting the infestation problem in deer.

J. J. Dent, game warden in Kerr county, reported that in 1935 he personally treated 50 deer with cases of screwworms on various ranches in Kerr county, and that he has frequently seen other deer with cases but was unable to catch them and administer treatment. This statement is quite indicative of the toll of deer that screwworms take, and especially when it is considered that they are wild creatures, and man can only hope to see a small percentage of the infested animals.

Other animals.—No authentic records have been secured of infestations of *Cochliomyia americana* in the various other species of wild animals, but many people have reported seeing screwworm cases in badger, raccoon, coyote, armadillo, mountain lion, wildcat and fox. There does not appear any good reason for doubting these observations, and very probably the species of larvae involved was *C. americana*.

There are authentic records of infestations of *Cochliomyia americana* in tamed coyotes and in dogs, house cats and domestic turkeys. Nothing has been learned regarding screwworm infestations of ground squirrels, rock squirrels, red squirrels or rats.

Control.—Possibilities of the control of screwworms in wild animals are not encouraging at the present time. The ranchman is treating from 90 to 100 per cent of his infested livestock for screwworms, but in wildlife few if any wounds receive treatment. Infested wild animals in parks or captured infested animals should be treated just as livestock, and maggot-infested carcasses of such animals should be promptly burned. A high degree of control of screwworms in livestock should result in a reduced number of infestations in wildlife. Wounding of animals when hunting should be avoided. Barbed wire fences are a source of trouble for deer and should be eliminated, or should be built high enough to prevent deer from jumping over them. Control of the screwworm in wildlife by means of natural enemies may offer possibilities.

Summary.—The cottontail, the jack rabbit, the opossum and the deer were found to harbor natural infestations of the screwworm, *Cochliomyia americana*. A total of 37 cases of myiasis in wild animals were studied. The fact that wildlife serves as a considerable source of infestation of the screwworm makes more difficult the control in livestock. Four per cent of the rabbits may carry infestations of *C. americana*. The predisposing causes which render animals subject to fly attack are rabbit bots, gunshot wounds, boils, disease, birth of young, injury by predators, fighting and brush and wire cuts. Infested wild animals should be treated whenever practicable and maggot-infested carcasses promptly burned. Effective control of screwworms in livestock should result in fewer attacks on wildlife.—3-4-37.

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Flight Tests on Screwworm Flies

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What is the flight range of the primary screwworm fly, *Cochliomyia americana* C. & P.? This question is partially answered in the following discussion, which is a progress report on the investigation of the flight of this insect that has been undertaken at Menard, Tex. During the period August 28 to October 22, 1935, five tests were conducted. In these tests 140, 000 adult *C. americana*, one to three days old, reared on live sheep and goats, were colored with finely powdered red chalk and liberated. The distance of flight was determined by placing steer yearlings having necrotic wounds infested with *C. americana* larvae and meat-baited flytraps at varying distances from the point of liberation, capturing practically all flies that visited the wounds and flytraps, and examining them for marked specimens.

Method of marking and liberating flies.—A cage containing laboratory-reared adults one to three days old was placed in a cloth bag at the point of liberation, about one-fourth ounce of finely powdered red chalk or a paint pigment was sprinkled on the flies through the screen wire, and the cages were gently inverted several times to insure the flies' being well-marked and easily identified. The cages were then opened and the flies allowed to leave of their own will or were gently shaken out. When the flies emerged from the cages they were all distinctly colored, the marjority being a brilliant red.

Apparently the marking agent had no injurious effects on the flies since a cage of adults colored and kept in confinement under observation had a rate of mortality no higher than that of the check lot.

Action of flies when liberated.—All liberations were made on a ranch 12 miles west of Menard, Tex. It was noted that when the air temperature was 76° F or above the liberated flies were very active; many of them took to the air immediately and flew upward in all directions for about 10 or 15 feet, or above the surrounding trees, and then began flying parallel to the ground. Even though the day was warm, some of them flew but a few feet to grass, brush or trees, where they remained, sometimes for several hours, preening themselves. When the air temperature was around 65° F at the time of liberation, the adults were very inactive and had to be forced from the cages. Before attempting to fly, they then crawled around on the ground until the temperature increased. Special precautions were taken not to transport any colored specimens from points of liberation.

There was little or no wind at the time liberations were made; therefore no observations could be made on the flight actions of *C. americana* in regard to wind direction. They seemed to fly freely in all directions without regard to the gentle breeze that prevailed during several of the liberations.

Experimental data. TEST NO. 1.—On July 28, between 6:45 and 7 a.m., 20,000 adults of *C. americana* one to three days old were colored with finely powdered red chalk and liberated 200 yards from a central recovery point. The liberation was made in the following manner: 5000 colored specimens each were released in north, south, east and west directions from the recovery station. Liberations on the north and south were made in open mesquite flats, on the west in the edge of a rocky draw where a medium amount of brush was present, and on the east on the side of a low hill rather densely covered with live oak brush.

The recovery station was located in an open grove of medium-sized mesquite trees situated in a flat between two low hills. A yearling steer with a necrotic wound containing several hundred second and third-stage *C. american* larvae was confined in a small corral at this point. Practically all flies that visited this attractive wound were captured and determined as to species. All *C. americana* were examined under a microscope for traces of red chalk. To test the efficiency of flytraps as a means of recovering colored specimens, four standard cone-type flytraps were placed 20 feet from the animal (one in each of the four directions). These traps were baited with meat baits in a .5 per cent solution of sodium sulfide. This test was conducted in the same location for a 10-day period, July 28 to August 6. A 24-hours' catch in the traps was considered a sample. The traps were emptied at 5 p.m. each day.

The first marked specimen captured on the animal was taken 17 minutes, and the second specimen 46 minutes, after the first flies were liberated.

In this test 122 marked females and four marked males were recovered on the animal, while only three marked females were captured in the meat-baited flytraps. Of the 126 marked specimens recovered on the animal, 114 were captured before 1 p.m. on the first day.

During the 10-day period in which this test was conducted 63,121 specimens of flies were taken on the recovery animal. Of this number 361 were *C. americana* (126 marked and 235 unmarked specimens) and 62,267 were *Cochliomyia macellaria* Fab.; 168,689 specimens were taken in the four standard cone-type flytraps, and of this number 111 were *C. americana* (three marked and 108 unmarked specimens) and 161,922 were *C. macellaria.*

TEST NO. 2.—On September 2, between 6:30 and 6:45 a.m., 24,000 *C. americana* and 57,000 *C. macellaria* adults one to three days old were colored with finely powdered red chalk and liberated at a central point.

The points of recovery were located 2 miles from the point of liberation in north, south, east and west directions. At each recovery station a yearling steer with a necrotic wound infested with *C. americana* larvae on the hip was observed from 7 a.m. to 5 p.m., and practically all flies visiting the wound were captured.

A standard cone-type flytrap was operated at each of the recovery

stations, and another flytrap was operated 1 mile beyond the recovery station in each direction.

Because of unsettled weather conditions the test was discontinued, except for the operation of the flytraps, after the first day.

The important results of this test are enumerated below:

1. No colored *C. americana* were captured.
2. Sixty-seven unmarked *C. americana* that were visiting the wounds were taken.
3. During 10 days, in which 14.4 quarts of flies were caught, 34 unmarked *C. americana* were taken in the four traps 2 miles from the point of liberation.
4. During 10 days, in which 9.1 quarts of flies were caught, 73 unmarked *C. americana* were taken in the four traps 3 miles from the point of liberation.
5. Forty-eight marked and 14,217 unmarked *C. macellaria* were taken visiting the wounds.
6. The first marked *C. macellaria* was captured on the animal at the south recovery station 2 hours 49 minutes after liberation.

TEST NO. 3.[1]—Since weather conditions prevented the continuance of test No 2 after the first day, this test was repeated on September 20 in every detail except that 43,000 colored adults of *C. americana* one to three days old were liberated. The liberation was made at 7 a.m.

Because of unsettled weather conditions this test was discontinued after the first four days.

A summary of the results for the first four days of test No. 3 follows.

1. The first colored *C. americana* was taken on the north steer at 11:12 a.m., 4 hours 12 minutes after liberation. One minute later, at 11:13 a.m., the second colored *C. americana* was taken on the south steer.
2. Eighty (three male and 77 female) colored and 375 (10 male and 365 female) uncolored *C. americana* were captured on the wounds of the steers 2 miles from the point of liberation.
3. The 2-mile traps, which were some 20 yards from the recovery steers, caught 68 quarts of flies, which contained 4 (one male and three female) marked and 72 (one male and 71 female) unmarked *C. americana*.
4. The 3-mile traps caught 21 quarts of flies, which contained no marked and 51 (all female) unmarked *C. americana*.

TESTS NOS. 4 AND 5.[2]—Since test No. 5 was a continuation of test No. 4, the results of both will be discussed together.

On October 10, at 7 a.m., 22,000 adults of *C. americana* one to three days old were colored and released, and on October 17, between 3 and 3:45 p.m., 31,000 additional adults of *C. americana* one to three days old were colored and liberated. These tests were conducted in the same manner as the previous ones with the exception that when a colored specimen was captured at one of the recovery stations all stations were moved 1 mile farther from the point of liberation that night or next day.

Some of the important results of these tests are presented as follows:

[1] Roy Melvin assisted with this test.
[2] E. W. Laake and J. T. Bigham assisted in these tests.

On October 10 the recovery stations were 3 miles from the point of liberation. No colored specimens were taken on that day. On October 11 at 4:18 p.m. one colored female *C. americana* was captured at the east recovery station. On October 12, 4 miles from the liberation point, three colored females were taken, two of these at the east station and one at the west station. On October 13, 5 miles from the liberation point, a colored female was captured at the east station. No colored specimens were taken on October 14. On October 15, 6 miles from the liberation point, one colored female was taken at the west station. No colored specimens were taken on October 16, and 17. The south recovery station was discontinued on October 16. On October 18, 7 miles from the liberation point, one colored female was taken at the north recovery station, and on October 19 at the same distance three colored females were captured. On October 20, 8 miles from the liberation point, three colored females were taken at the east recovery station. On October 21, 9 miles from the point of liberation, one colored female was taken at the east station, and on October 22 two colored females were captured at the same distance and at the same station.

These tests were discontinued on October 22 because of cold and unsettled weather conditions.

Conclusions.—Adults of *Cochliomyia americana* C. & P. are capable of flying 9 miles. Necrotic wounds in yearling steers, infested with larvae of *C. americana*, are more attractive to liberated *C. americana* than are meat-baited flytraps.—3–4–37.

Mosquitoes of Southeastern Arkansas

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The mosquitoes of southeastern Arkansas were studied from the standpoint of the seasonal occurrence, distribution and relative economic importance of the several species. The work was done during the years 1935 and 1936,[1] at which time collections were made from representative habitats at intervals in that part of the coastal plain from the Saline river east to the Mississippi river and from the Arkansas-Louisiana line north to the latitude of Stuttgart, which is in the east central part of the state. More details about topography and methods of collecting are recounted in a previous paper (Horsfall 1936).

The two seasons differed greatly insofar as the climatic factors were concerned. The first, 1935, was an average season in which there was an abundance of rain in the spring and fall and a shortage of rain throughout the summer months. Temperatures throughout the year were about normal. The latter, 1936, had little rainfall on the whole. There were no floods even in the spring. May and June were exceptionally dry. In July, however, at Monticello, very heavy rains amounting to 7.44 inches fell during the first four days, which caused much flooding of hill streams

[1] Data for this paper were obtained while the writer was at the Agricultural and Mechanical College at Monticello. The work was made possible in part because of a grant from the National Research Council and in part because equipment and assistance was furnished by the college.

and near floods in the bayous and rivers. Following this small unseasonable deluge was a prolonged drought with only 3.87 inches of rain from July 5 until October 7.

Twenty-nine species[2] of mosquitoes were reared or collected in southeastern Arkansas during the two seasons, 1935 and 1936. They may be arranged into groups of species according to the time of occurrence as follows: spring only, normally spring and occasionally at other times, summer only, summer to fall, fall only, winter, and spring to fall. The strictly fall and strictly winter groups consist of a single species each. The group which ranges in its occurrence from spring to fall and that which occurs in the summer are each composed of nine species.

Spring species.—The spring group is composed of *Aëdes canadensis* Theobald and *A. thibaulti* Dyar and Knab, two locally important species. Both annoy warm-blooded animals in woods along water courses at the time of their occurrence. The former species is more widespread and more abundant numerically than the latter because it develops in all sorts of woodland pools. On the other hand, *A. thibaulti* passes its immature stages in the hollow bases of trees which are flooded at a time of high water. Since only a few of such trees occur along the streams, the adults are much less abundant than those of *A. canadensis*. They remain close to the tree from which they emerged and bite viciously when one comes within their range.

The variation in the distribution and amount of rainfall between 1935 and 1936 brought about discrepancies in the time of occurrence and sequence of these species. The larvae of *A. canadensis* appeared first about the middle of February in 1935, and the adults about the middle of March, which was about one-half month earlier than in 1936. Emergence continued until near the end of April, and the last adult was collected May 5, 1936. Aside from the delayed appearance, this species ran much the same course in the two years. *Aëdes thibaulti*, on the other hand, was collected only in 1935, when its period of emergence came during the month of March. In the case of both species there was but one generation and one brood each year.

Spring to summer species.—The other group which occurs normally in the spring is composed of *Psorophora posticata* (Wiedemann), *P. varipes* (Coquillett), *Aëdes dupreei* (Coquillett)?, and *A. hirsuteron* (Theobald). All are flood-water species which occur normally in the woods near their breeding places like the foregoing group. *Psorophora posticata* occurs both on the hill land and in river bottoms in about equal numbers, whereas *P. varipes* is normally an inhabitant of the woods along larger streams and rivers. Little can be said of the two species of *Aëdes* in this group because they did not occur in sufficient numbers to state where they are generally found.

This group of species was separated from the others because of the variation in the time of occurrence from location to location and from the one year to the next. In 1935, the normal spring rains caused sufficient flooding of such drainage basins as those of the Saline river and Bayou Bartholomew to bring out the two species of *Psorophora* in abun-

[2] The author is indebted to Dr. Robert Matheson of Cornell University for reviewing determinations of certain species.

dance in May and early June. However, there was little high water in the Arkansas river bottom until early July, when as a result of heavy rains in states to the west the river overflowed its north bank in southern Arkansas county and flooded many square miles of woodland. As soon as the water had partly receded *P. varipes* adults were present in swarms in conjunction with a few *P. posticata* and *Aëdes hirsuteron*. In 1936 only *P. posticata* was found during May, and not until the end of the early July rains was *P. varipes* found. Even then there were very few of the latter species in comparison to the swarms of the previous year. Both *Aëdes hirsuteron* and *A. dupreei?* appeared in such small numbers both years that little can be said of their exact time and place of occurrence. All of these species appear later than the early spring group and are very annoying in the woods near their breeding places.

Summer species.—The nine summer species may be separated into those which breed solely in transient water and those which breed in permanent or semipermanent water. Included in the former group are *Psorophora columbiae* (Dyar & Knab), *P. discolor* (Coquillett), *P. signipennis* Coquillett, *P. ciliata* Fabricius, *P. howardii* Coquillett, *Aëdes infirmatus* Dyar & Knab, and *A. atlanticus* Dyar & Knab. Those which breed in water of a more permanent nature are *Culex inhibitator* Dyar & Knab, and *C. peccator* Dyar & Knab. For the most part the species of the former group breed in pools which were formed by heavy rains and which disappear within a few days. With the exception of *Psorophora howardii*, *Aëdes infirmatus* and *A. atlanticus*, the larvae of the summer species were found in pools away from woods where in many cases, the pools were exposed to direct sunlight. The two species of *Aëdes* and *Psorophora howardii* bred, for the most part, in partially or heavily shaded pools. Throughout the two summers, larvae of all of the species of *Psorophora* of this series were collected after sufficient rains had fallen to flood the shallow depressions where the eggs had been laid previously. Especially do they develop in enormous numbers in the counties where land is devoted to rice culture. There the alternate flooding and partial drying of the fields result in ideal conditions for oviposition and development. *Culex inhibitator* occurs along with the *Psorophora* species in enormous numbers in rice fields. The shallow water and an overgrowth of aquatic vegetation make ideal breeding places.

From late May until early October active stages of the summer series were collected. *Psorophora columbiae*, the earliest to be collected, was found as third instar larvae May 23, 1936, in freshly flooded roadside ditches. The others appeared during June and July in both years.

The latest record for any species was that for a brood of *Psorophora ciliata* which emerged in early October. Only where rice was grown was there any tendency of an increase in numbers as the season advanced. Apparently the summer drought prevents the building up of the population elsewhere.

Aëdes infirmatus and *A. atlanticus* were reared from only one collection of larvae from a temporary woodland pool in July 1936. This same pool had been under observation for both years, and although it had been flooded many times in the interval, no larvae had previously been collected.

Summer to fall species.—A few of the species, such as *Culex quinquefasciatus* Say, *C. tarsalis* Coquillett and *Anopheles barberi* Coquillett, begin to appear in early summer and increase in numbers until frost. Only *Culex quinquefasciatus* was of any great economic importance during the years covered by this study. Small pools such as refrigerator and lavatory drains, unused water closets and water from other domestic sources provide excellent breeding places for this *Culex*. As the adults emerge from the pools they fly to dark damp places such as barns, outhouses, chicken houses and dwellings, and at night they attack whatever warm-blooded animals are available. The other *Culex* breed in transient and permanent pools without regard to dwellings. *Anopheles barberi* is a rare species which breeds in holes in stumps and trees in woods. No observations were made regarding its feeding habits or the habits of *Culex tarsalis*.

The house mosquito of the south, *Culex quinquefasciatus*, was found to vary considerably in its time of occurrence in the years 1935 and 1936. In 1935 the adults began to appear in small numbers in June, but in 1936 none were found until October. In late October they appeared in swarms in houses and barns. The very hot dry summer of 1936 may serve to explain the delayed appearance of this most common and generally annoying mosquito of southern Arkansas. There was no rain in June; then following the heavy rains of early July there was none until September 21, at which time 1.61 inches of rain fell. Again on October 7 a precipitation of 3 inches left a great deal of standing water. Previous to these rains the soil was so dry that water in normal breeding places sank rapidly into the soil and therefore failed to suffice. In both years the swarms of adults in the fall persisted well into December, and in 1936 oviposition was observed as late as December 3.

The other two species in this series showed a similar increase in numbers until late fall, but the time of latest oviposition was not observed. *Anopheles barberi* was reduced in numbers during periods of drought when the stump holes were dry. Whenever water was available they continued breeding. In 1936, water was provided continuously throughout the dry summer in bottles in stump holes and larvae were found in the bottles at each observation. With these three species then an important factor limiting their increase was the lack of rainfall.

Fall species.—Only *Theobaldia melanura* Coquillett seems to be limited to occurrence in the fall. Larvae and pupae were found in abundance in October and November in open pools on muck land after the fall rains began. Some of the larvae which were placed in a partially buried bottle late in November persisted throughout the winter but none emerged as adults. The importance of the species is doubtful.

Winter species.—Only *Theobaldia inornata* (Williston) is a strictly winter species, which breeds in pools containing large amounts of organic matter, such as those about slaughter houses which contain blood refuse. Egg masses, larvae and pupae were collected from early December to March, during which time the larvae and pupae were always active even when the water was coated over with ice. Adults emerged during the periods of warm weather all through the winter. While the

species seems to be of no economic importance it is of interest because of its time of occurrence.

Spring to fall species.—The following nine species showed a tendency to vary in numbers according to rainfall from early spring until late fall rather than a tendency to vary with the season. These are *Aëdes triseriatus* (Say), *Orthopodomyia signifera* (Coquillett), *Megarhinus septentrionalis* Dyar & Knab, *Culex territans* Theobald, *C. salinarius* Coquillett, *C. apicalis* Adams, *Anopheles quadrimaculatus* Say, *A. punctipennis* Say, and *Aëdes vexans* (Meigen). Periods of heavy rainfall were followed by an increase in the numbers of adults of these species. Since all of these except *Aëdes vexans* breed in permanent pools as well as in transient ones, their increase in numbers of adults resulted from a larger number of breeding places. *Aëdes vexans*, however, developed only in transient pools; therefore, adults were found only after flooding of the places where their eggs had been laid.

The three species which inhabit holes in trees were active every month in the year, but they tended to be abundant according to seasons. *Orthopodomyia signifera* and *Megarhinus septentrionalis* increased in abundance during summer and fall, after which they decreased. Neither the rise nor the fall of the water affected the abundance of the larvae of either species because they oviposited on the water. On the other hand, the larvae of *Aëdes triseriatus* were the more numerous during the period of the spring rains. The adults began to appear about the middle of April, and the period of their greatest abundance was usually during early May. Lowering of the water level in the holes during the summer months caused a continued decrease in the hatching of larvae until the fall rains raised the water level.

Of the three species of *Culex* in this series, *C. territans*, a semidomesticated species, was the only one which appeared in abundance. It appeared first in April and continued in abundance usually throughout May and early June. Larvae have been collected from April until December in all kinds of semipermanent and transient pools which contained clear or foul water. In the summer larvae were occasionally taken in tree holes and artificial containers.

Anopheles quadrimaculatus and *A. punctipennis* larvae were widely distributed over the entire coastal plain of the state but were never found concentrated in great abundance in the field. From early spring until December they could be found among floating aquatic vegetation in all sorts of pools. The larvae of the former were collected more generally in river bottoms and other regions where the land is nearly level. In the case of *A. punctipennis*, however, this difference in distribution between the region of rolling hills and that of more level terrain is less obvious. The overwintering adults of both are known to become active by March 1, as shown by collections of them in the field at that time.

Aëdes vexans is the only flood-water species of mosquitoes which is not closely limited to a particular season. A brood may appear in any month from late May to October. The three principal broods that were noted appeared in June, July, and September or October. In none of these cases were the larvae collected from the same pools at the different

times during a year, therefore, it cannot be said that the species has more than one generation per year. There are indications, however, that in a year of normal rainfall the species tends to have a brood in the early summer and another in the fall.

Summary.—Of the 29 species of mosquitoes which were collected in southeastern Arkansas, 14 are of economic importance. Adults occur every month of the year, but none of economic importance is active during January and February. The economic species occurring during the other months are as follows: March, *Aëdes thibaulti* only; April, *Aëdes canadensis* and *A. triseriatus;* May, *A. triseriatus, Psorophora varipes, P. posticata* and *Culex territans;* June, *Aëdes vexans, P. varipes, P. columbiae, P. ciliata* and *P. discolor;* July, the same species as June, and in addition *P. signipennis, Anopheles quadrimaculatus* and *A. punctipennis;* August, the same species as July, except *P. varipes,* and in addition *Culex quinquefasciatus;* September, the same as August, except *P. discolor* and *P. signipennis;* October, *C. quinquefasciatus, P. ciliata* and *A. vexans* reappearing; November and December, *C. quinquefasciatus.*

The most accute mosquito problem occurs in the rice district and in the broad valleys along the rivers and bayous. Woodland species occur after heavy rains from March to October. House mosquitoes occur from May until December.—3-4-37.

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Flat-headed Apple Tree Borer in Oklahoma

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The flat-headed apple tree borer, *Chrysobothris femorata,* is one of the most important shade and fruit-tree insect pests in Oklahoma. It is especially injurious to recently transplanted elms, apple and pecan trees. In recent years it has caused considerable injury to rose bushes and it has killed many large-sized elms throughout the state. In Oklahoma the insect is a major problem because of the dry climate of recent years and unfavorable soil conditions.

Records kept at Oklahoma A. and M. College show the beetle has been collected in 14 counties in widely separated parts of the state from the southeast to the panhandle sections. This indicates the beetle to be present throughout the state. Correspondence concerning injury by flat-headed borers which can be definitely referred to this species show records from all but a few counties. Most of the records, however, are from the central and northeastern parts.

During the fall and winter of 1935–1936 large numbers of injured branches and small trees were collected from time to time and kept outside where they were exposed to normal weather conditions. Exami-

nation showed the borer to be in the larval stage deep in the heartwood in most cases. This material was caged in the spring and, when the beetles started to emerge, the cage was examined every day and the number of beetles which had emerged during the previous 24 hours recorded. The first beetles emerged May 4 and the last June 29. A total of 669 beetles emerged during this period, fig. 1. The emergence curve is rather irregular but shows three rather well defined peaks occurring on June 16, 21 and 30. Records of collections obtained during an insect survey show the

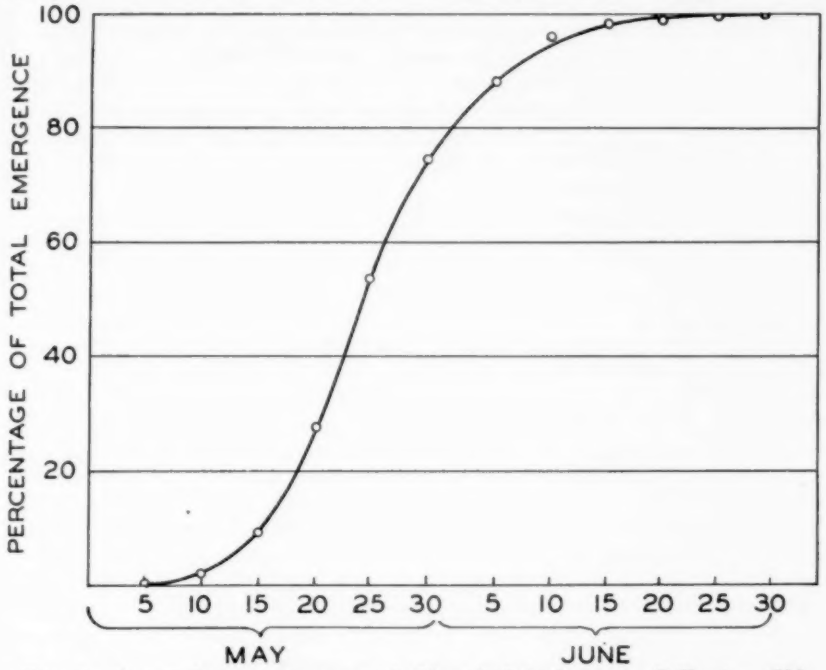

Fig. 1.—Accumulative emergence of *Chrysobothris femorata*, Stillwater, Okla. 1936.

beetles to be flying from April 20 to October 9, both date extremes being from Stillwater. Fifty-one out of the 67 collection records are for June.

Insect cages consisting of a lantern chimney placed on a 6-inch flower pot, which contained a 4-ounce bottle of water to keep the twigs and cuttings fresh, were used to confine the beetles for study. Apple and elm cuttings were used as food and the beetles were placed in the cages as soon as they emerged. The cages were kept on a sunny bench in a greenhouse. The beetles fed very readily on the bark of one-year old apple and elm cuttings, especially in crotches and around bud scars. Although the cuttings very often had twigs with leaves attached, the beetles did not feed on the leaves. An interesting feature discovered was the drumming habit which was observed very commonly to take place on about the second or third day after emergence. With several cages each containing several pairs of beetles arranged along the bench in the sun the activities

of the beetles could be readily observed. The sound was very audible especially as the glass chimney acted as a sort of sounding board. The drumming was very rapid and made by the insect vibrating its abdomen up and down against the surface upon which it was resting. It appears to be a mating call, as the sexes were attracted and mating followed.

The preoviposition period was found to be four to eight days, with an average of 5.8 days. A shortage of food during the first few days after emergence caused a longer preoviposition period. Beetles that were not fed lived only a few days after emergence.

The females seem very selective when choosing a place to deposit their eggs. They were observed running up and down on the sunny side of the limbs, working their short ovipositors in and out over the surface of the bark, and stopping only when the ovipositor would strike an uneven surface. Cracks and sun-scald checks seemed very suitable and the first eggs would be placed in such places. It would take about 10 to 30 seconds for the female to deposit the egg after a desirable place was found. The total number of eggs obtained from individual females varied from 21 to 166 with an average of 65.7 from a series of females. The average number of eggs laid each day by the entire series of beetles varied from 0 to 69 with a close correlation to temperatures, the warmer the day the greater being the number of eggs deposited.

Longevity of the beetles was rather difficult to determine as there were several factors that might influence this. No actual field checks were made to verify the results obtained. It was necessary to transfer the beetles from one cage to another every day, so that the handling was probably an important factor. Also the temperature inside the glass cages might have become too high. However, several individuals lived for approximately 40 days and a maximum of 44 days was recorded.

Four other species of beetles were reared from the caged material. They were *Anthaxia viridifrons*, which is a very small buprestid; *Neoclytus acuminatus*, a small cerambycid; and two species of corynetidae, namely, *Chariessa pilosa* and *Chariessa pilosa onusta*. The last two were predaceous on the flat-headed borers in both larval and adult stages. About 6.9 per cent of the flat-heads collected in the larval stage in the winter and spring of 1936 were parasitized by a species of Ichneumon wasp.—7-26-37.

Analysis of Attrahent Factors in Fermenting Baits Used for Codling Moth

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Fermenting baits have been used to attract the codling moth, *Carpocapsa pomonella* L., partly as a supplementary method of control, but more generally to determine spraying schedules. Among the investigators who have done previous work are Fowler (1930), Yetter (1925), Yothers (1927), Eyer (1935) and Van Leeuwen (1935).

In experiments carried on by these men, particularly Yetter and Van Leeuwen, there has been a tendency to approach the problem by adding various compounds to the stock solution of bait. By such methods proggress is made in increased catches and a superior bait may be thereby devised, but little has so far been added to our knowledge of what actually is the basic attrahent or its combinations. In contrast to these methods the procedure at the New Mexico Agricultural Experiment Station has purposely departed from regular field trials involving the haphazard adding of compounds to bait pails. Two new principles have been developed: First, laboratory tests were made on the effectiveness of compounds synthesized from various alcohols and acids; second, these tests were conducted by means of an insect olfactometer specially adapted for the adult codling moth. By this method of investigation a preliminary analysis of the processes involved in fermentation and the chemotropic responses of the codling moth to alcohols, acids and esters which are formed by such fermentations is being made. Certainly there must be a definite, although perhaps elusive, factor which makes such baits attractive. Previous investigators have made partial analyses, but thus far nothing definite is known.

Fermentations are defined as peculiarly slow decomposition processes of organic substances.As a rule carbon dioxide and other gases are liberated. These gases must arise from the acids and alcohols, their complex homologues, and from the innumerable combinations of intermediate and end products. It is readily seen that unless some method of systematic study is followed there can be only the proverbial needle-in-the-haystack search for the unknown attrahent.

Von Lippmann (1904) in his studies of fermentation listed a large number of acids and alcohols which are actually formed by the hydrolysis of sugars such as those found in molasses baits. A few of the alcohols are methyl, ethyl, propyl, butyl and amyl groups, with their isomers. The acids most abundant belong to the fatty acid series and include those with the least number of carbon atoms in their chain. In addition, other forms such as the dibasic and more complex hydroxy acids can be formed. Succinic acid is found in rather appreciable amounts, and it is probable that benzoic, oxalic, malic, tartaric and other acids of their series are present in ferments.

By a combination of an acid and alcohol a product known as an ester is formed. It is interesting to note that combinations of the acids and alcohols listed form many of the so-called fruity esters—compounds found in many fruits which are decidedly aromatic and pleasing in smell. The study of a series of these esters has been the basis for the investigation covered in this report.

Apparatus and methods.—Olfactometers have been described by other investigators. McIndoo (1926) tested the reactions of potato beetles to certain stimuli in a specially devised olfactometer. A much improved type was used by Ripley & Hepburn (1929) in their tests involving the attractiveness of baits to the Natal fruit fly. Eyer (1933) at the New Mexico Agricultural Experiment Station perfected an apparatus for codling moths to be used in relation to the phototropic responses of the insects. With a few changes this was used to test the chemotropic re-

sponses. The olfactometer consists of eight radiating arms which lead into a large round central chamber. At the end of each arm a screened opening allows a gentle circulation of air to be maintained by a fan sucking at the bottom of the central cage. A quart jar can be attached to the underside of the end of each arm. Compounds to be tested are floated on water in the jars by means of small vials set in corks.

In order that specimens might be obtained for experimentation, codling moth larvae captured in bands during the summer and fall of 1935 were overwintered in small vials plugged with cotton. After their emergence in the spring of the following season, definite numbers of

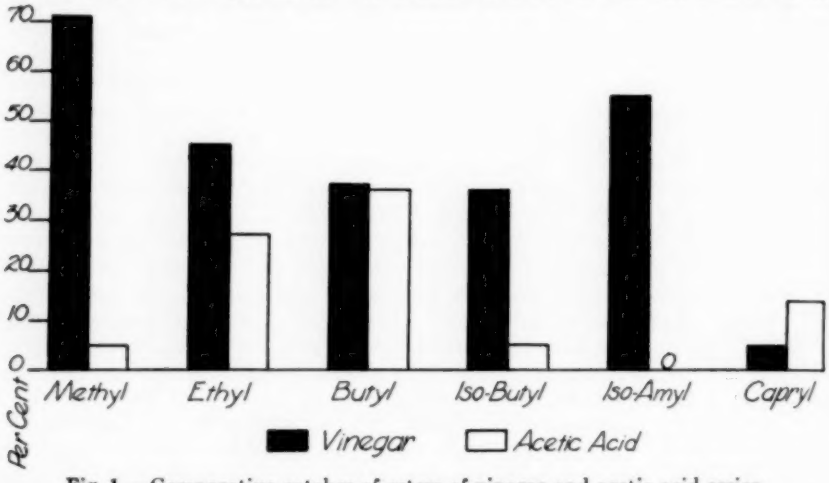


Fig. 1.—Comparative catches of esters of vinegar and acetic acid series.

the adult moths were liberated in the olfactometer. Responses of the moths to various substances are indicated by the numbers caught in the water of the jars containing the vials of bait. Experiments were always started at sundown, the time of maximum flight activity, and allowed to run overnight. Effectiveness of each bait was expressed in per cent of the total number of moths attracted to the entire series of baits used.

Experiments by Cook (1926) have shown that some correlation may exist between the chemical structure of compounds and their attractiveness. Accordingly, the esters used in the experiments at the New Mexico Agricultural Experiment Station were prepared, insofar as possible, in definite series, and grouped by their physical and structural constants. Two main series were used in the preliminary work. The first was based on findings of previous field tests that a substance known as ethyl oxyhydrate, synthesized from ethyl alcohol and either vinegar or sugar, was very attractive to the codling moth. The name ethyl oxyhydrate means nothing when analysed for chemical structure, but it is thought that the product is an impure form of ethyl acetate. Others of the so-called oxyhydrates were made from a series of alcohols. For comparison, the same series was made with glacial acetic acid. The correlation of the catches is shown by fig. 1. It is interesting to follow the decreasing trend

of the catch-curve as the number of carbon atoms in the alcohols increases, and to note that the vinegar esters are more attractive than those of the corresponding acetic form. Is there a clue in the apparent superiority of a bait derived from an apple base over one which is probably much the same in structure, but synthesized in a pure form? Does a fermenting bait liberate the same odors as those which come from the apple and prove to be such a powerful attrahent to the codling moth?

Tests of the second group of esters were limited to the combinations of pure alcohols and acids in various series. In fig. 2 a comparison is made between the ethyl and methyl alcohols in series with several acids. Most of the baits were attractive to some degree. The combinations with

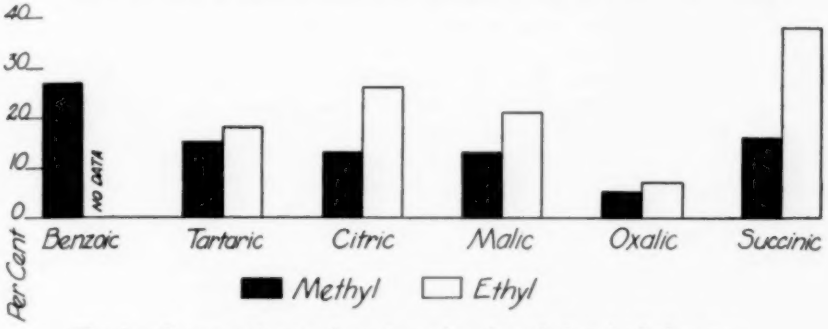


Fig. 2.—Comparative catches of a series of methyl and ethyl esters.

succinic and benzoic acids indicated a decided attractiveness. Here again it would seem that a definite correlation might be found when it is remembered that succinic acid is formed in relatively large amounts in fermentation products, and that it has been reported by Eyer & Rhodes (1931) that the addition of sodium benzoate has a stimulating effect in baits. However, in a preliminary report of this type conclusions can not be drawn on olfactometer results alone and not until careful checks are made and field tests can be run also. Nevertheless, a new field has been opened in the investigations on the chemotropic responses of the codling moth. Further tests are in progress at the New Mexico Agricultural Experiment Station, involving a larger and more complete series of these compounds, supplemented by various orchard tests with baits containing the products which show some indication of being attractive. By such methods it is hoped that knowledge may be gained of what actually is the factor or factors making the fermenting baits attractive.

Bacterial flora related to fermentation in codling moth baits.—In the early fermentation studies, Peterson (1924) used yeast as the fermenting agent in molasses baits. Later, however, it was observed by Peterson (1926) and also by Frost (1926) that such baits were equally attractive when allowed to ferment through the action of mixed cultures of the so-called "native yeasts" from the surrounding atmosphere. Investigations in New Mexico by Eyer & Rhodes (1931) added the information that although codling moth catches were directly correlated with the gas

evolution, the maximum catches were not necessarily obtained at the period of highest yeast population.

This suggested the possibility that bacteria may also be capable of producing fermentation and the production of attractive substances in this type of bait.

During the spring and summer of 1936, 10 per cent *Brer Rabbit* syrup solutions were placed in 2-quart conical pails and suspended from crossbars in the tops of apple trees in the New Mexico Agricultural Experiment Station orchard and allowed to ferment under normal conditions. From the beginning of the experiment until fermentation had ceased, samples of the syrup solutions were taken periodically and plated out by the dilution method. All organisms present were isolated. Then the isolated organisms were grown in sucrose, dextrose and levulose fermentation tubes to compare their gas producing capacity. The three sugars were used because sucrose, which is the chief carbohydrate constituent of cane syrup, hydrolizes to dextrose and levulose. Those organisms that were found to produce both acid and gas were saved for further study while the others were discarded. A total of more than 200 organisms were isolated from the bait material. Disregarding the yeasts and nonfermenting bacteria, seven distinct strains of bacteria were found to be aerobic spore formers belonging to the family *Bacillaceae* and the genus *Bacillus*. Two of the species have been identified as *Bacillus polymyxa* and *Bacillus aerosporus*. The exact species of the other five organisms have not as yet been determined, and so are tentatively designated as species 1 to 5.

To recheck the isolated bacteria, to ascertain whether their fermentative products were attractive to the codling moth, they were grown in pure culture in sterile sucrose broth using 125 cc. Erhlenmeyer flasks. After heavy growths were obtained, sterile 10 per cent *Brer Rabbit* syrup solutions in wide-mouth quart fruit jars were inoculated with each of

Table 1.—Comparison of the attractiveness of codling moth baits inoculated with different species of *Bacillus*.

Organism	Total No. Moths Caught	Days Exposed	Av. Daily Catch
Bacillus polymyxa	32	8	4.
Bacillus aerosporus	17	8	2.1
Bacillus No. 1	82	10	8.2
Bacillus No. 2	40	10	4.
Bacillus No. 3	57	10	5.7
Bacillus No. 4	35	8	4.3
Bacillus No. 5	39	8	4.9
Check	33	10	3.3

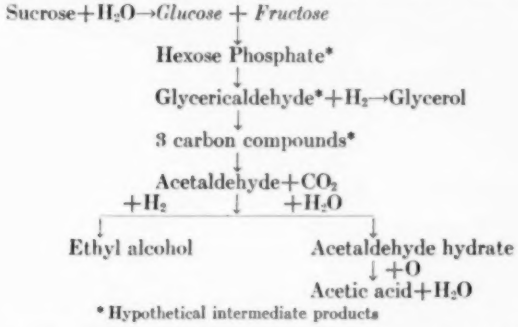
the species. When the syrup solutions had begun to ferment under controlled laboratory conditions they were taken to the orchard and their attractiveness determined through the customary trapping procedure. The traps in this case consisted of dishpans tightly fastened to the upper limbs of apple trees, and the jars containing the baits were suspended in the center of these pans. The dishpans were then filled with water. This type of trap is advantageous in that it exposes a much larger surface

area than does the ordinary 2-quart conical pail. Check control baits of sterile 10 per cent cane syrup solutions which had been allowed to ferment under field conditions were simultaneously exposed in the same type of traps for comparison with the traps containing the bacterial cultures.

The codling moth catch of these traps is illustrated by table 1. It can be seen that the check bait had an average daily catch of 3.3 moths over a 10-day period, while *Bacillus* No. 1 had an average daily catch of 8.2 for the same time. On the other hand, *Bacillus aerosporos*-inoculated bait from this preliminary comparison was found to be less attractive than the check. All of the other baits appeared somewhat more attractive than the check. It should also be mentioned that these baits did not consistently catch the aforementioned number of codling moths throughout the season, for during cool rainy periods all traps caught few or no moths.

From these preliminary tests it would appear that cane sugar solutions fermented through the action of pure cultures of most of these high acid and gas-producing types of bacteria were more attractive to the codling moth than the same baits allowed to ferment through contamination by a mixed flora from the air. Further experiments are in progress to verify these results, using marked codling moths in cages and in the olfactometer described early in this paper.

In the problem of codling moth attraction, the importance of aromatic esters has been alluded to. Further to supplement the investigation of fermentation by bacteria, analyses are now being made of the principal acids, alcohols and esters produced by these various bacteria in pure culture. According to Buchanan (1930) the chief fermentation products of *Bacillus polymyxa* are acetic acid, ethyl alcohol, butylene glycol, carbon dioxide and hydrogen. The general scheme for the production of these fermentation substances is diagramatically expressed as follows:



* Hypothetical intermediate products

The actual fermentation process is somewhat theoretical because some of the intermediate reactions are not thoroughly understood. However, the first reaction in this process is the hydrolization of sucrose to glucose and fructose. The next three reactions from glucose, although hypothetical, are believed by Buchanan & Buchanan (1936), Werkman (1935) and others to occur. The acetaldehyde formed from the hypothetical three carbon compounds may proceed in either of two directions. It

may be reduced to ethyl alcohol by acting as a hydrogen acceptor to one of the intermediate products, or it may be hydrolized to form acetaldehyde hydrate. With oxygen serving as a hydrogen acceptor, acetaldehyde hydrate may then form acetic acid. This phase of the problem is still in the process of investigation and will be reported more in detail at a later time.—7-23-37.

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Pseudococcobius terryi Fullaway

A Hawaiian Parasite of Gray Sugarcane Mealybug in the United States

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About 1908 Terry found the sugarcane mealybug parasite *Pseudococcobius terryi* Fullaway parasitizing the gray sugarcane mealybug, *Pseudococcus boninsis* Kuwana, on one of the Hawaiian islands. It is not definitely known whether *P. terryi* is a native of the Hawaiian islands or whether it was sent from China by Muir but it is known to occur on

most of the islands of this group where its host is found. It has never been found parasitizing the pink sugarcane mealybug, *Pseudococcus sacchari* Kuwana, even when this latter is present on the same cane plant with the gray species. Both Swezey (1931) and Pemberton (1932) have reported it as an effective parasite of the gray sugarcone mealybug.

Importation from the Hawaiian islands.—In 1932 O. H. Swezey, of the Hawaiian Sugar Planters' Experiment Station, very kindly offered to make shipments of this parasite to the Bureau of Entomology for trial in the United States. The shipments were sent direct to T. E. Holloway, whose headquarters were in New Orleans at that time.

Parasitized mealybugs were shipped in glass tubes that were covered with cloth to retain the parasites but permit the entrance of air. These tubes were stored in the refrigerated rooms on the boats to protect the parasites from unfavorable temperatures and to retard their development. The shipments were dispatched from the port of arrival to New Orleans by air mail.

The parasitized mealybugs arrived in good condition and the parasite emergence was satisfactory. The newly emerged parasites were put in tubes with mealybugs that had been collected in Louisiana, and this host material was readily accepted for oviposition. It was soon found that the parasite was easy to handle and that it could be reared in numbers in the laboratory. A few generations were reared in 1932 by T. E. Holloway before all of the material was turned over to the writer.

Description and general habits.—The Hawaiian sugarcane mealybug parasite is a small yellowish wasp belonging to the family Encyrtidae. The male is about 1 mm. in length and the female slightly longer. The male seems to be more active than the female, and crawls rapidly for such a small insect, and is seldom observed resting. The female is also a fast crawler but is frequently observed to stand motionless for several minutes. Both sexes have been observed to fly readily in the laboratory, but for only short distances. No information is available as to the flight of either sex in the field, but it seems reasonable that they might fly a considerable distance with the aid of a favorable wind. Recoveries have been made as far as one-half mile from the point of release.

Oviposition.—When the female parasite was ready to oviposit, she approached the mealybug slowly and apparently with great care. In the cases observed, the parasite felt of the mealybug with the antennae several times before any attempt was made to insert the ovipositor. When the parasite was ready to insert the ovipositor the tips of the wings were folded back over the abdomen. The parasite then backed up to the mealybug with the ovipositor extended in an effort to locate the host. Frequently the parasite missed the mealybug with the ovipositor and would start all over again. This parasite has been observed to oviposit in all parts of the body of the mealybug except the head. The length of time required for oviposition ranged from two to 15 minutes. The parasite remained quiet while the ovipositor was inserted in the host.

The mealybugs did not seem to make any effort to avoid the parasite, either before the ovipositor was inserted or afterward, and they did not show any ill effect while oviposition was taking place or for some time later. Mealybugs have been observed to move about and pull the para-

site along while oviposition was taking place. The ovipositor was apparently removed with more difficulty from some mealybugs than from others. All stages of the host except possibly the first-instar nymph are acceptable for oviposition.

Several times a single female parasite has been isolated with a mealybug in order to observe the frequency of oviposition. In several instances a female parasite has been observed to oviposit twice with an interval of less than 5 minutes between punctures. One female was observed to insert the ovipositor a third time, the two intervals between ovipositions totalling not more than 10 minutes.

Developmental period.—This parasite has been reared through many generations in the laboratory in each season of the year. It has not been possible to devote enough time to this project to make daily observations on the length of the life cycle, but it is believed that fairly accurate data were secured. No attempt was made to record the length of the individual stages passed within the host. It was found that the average number of days required from the time of host exposure to that of parasite emergence was 33 for winter, 28 for spring and fall and 18 for summer. This time ranged from 16 days in summer to 40 in winter. All observations strongly indicated that the parasites started oviposition soon after host material was offered, in many cases within 10 minutes.

Number of parasites from a single host.—Several tests were made to determine the number of parasites that could be expected to develop in a single adult mealybug. The mealybug in each test was isolated with a single female parasite. The tubes were examined at intervals for parasites, and a final examination was made with a hand lens after emergence was completed. The maximum number of parasites that emerged from a single adult female mealybug was 19, with an average of 8.5. In several cases 10 or more emerged from a single host. This would indicate that the parasite is capable of building up a large population in a short time. These experiments did not give any reliable data on the number of eggs a parasite was able to deposit, but they indicated that a fair number could be expected. The parasitized mealybugs retained their normal shape, even when only the body wall remained.

Another host.—Specimens of another mealybug, determined by Harold Morrison as the *Pseudococcus citri* Risso of authors, was collected from the Japanese paper plant, *Tetrapanax paprifera* Koch, and exposed to the sugarcane mealybug parasite to determine whether it would be accepted as a host. The female parasites approached this species in the same manner as they did the sugarcane mealybug and readily prepared for oviposition. There was no apparent difference in the manner of inserting the ovipositor or in the length of time required for oviposition. Several parasites were reared from this species of mealybug, and they were apparently normal in size and activity.

Releases and recoveries made in Louisiana.—All of the Hawaiian sugarcane mealybug parasites released in Louisiana in 1932 were placed on three plantations. Several hundred, or about 90 per cent, were released on Southdown plantation near Houma. About 30 parasites were released on Alice C. plantation near Franklin and about 75 on Greenwood plantation about 3 miles north of Thibodaux. Small releases were

made in 1934 on three additional plantations—on Valentine and Georgia plantations near Lockport and on Elm Hall at Napoleonville. Releases were made in 1936 on still three other plantations and at the Louisiana Agricultural Experiment Station at Baton Rouge. The plantations that received parasites were Cinclare near Port Allen, Laurel Grove about 3 miles from Thibodaux, and Sterling at Franklin.

Apparently the parasite is well established on Southdown plantation, since recoveries have been made easily each year including 1932. The first recovery made on Alice C. plantation was in 1936. Several previous attempts were made to determine whether a colony had become established on this plantation. Recoveries were made in 1935 and 1936 from very small collections of mealybugs made on Elm Hall plantation and the parasite is believed to be well established on this plantation. Several collections of mealybugs have been made on the other three plantations where releases were made in 1932 and 1934 but the parasite was not recovered. No attempt was made to determine whether the parasite was established at the places where releases were made in 1936. A second release was made on Georgia plantation since all efforts to make a recovery at this place had failed.

Releases and recoveries made in Georgia.—Several hundred parasites were released in 1932 on the U. S. Department of Agriculture Experiment Station grounds at Cairo by W. E. Haley. A small additional release was made at the same place in 1933 by J. W. Ingram. The parasites were recovered at the station in 1934, 1935 and 1936, and must be well established at this place since they have been recovered without difficulty about one-half mile from the point where the release was made. A total of 22 parasites were released in August and September 1934 on the Roddenberry plantation near Cairo. No attempt has been made to recover the parasite here.

Releases and recoveries made in Florida.—Several hundred parasites were released in 1932 by W. E. Haley at the Florida Agricultural Experiment Station at Belle Glade. They were easily recovered in 1934 and 1936 about one-half mile from the point of release at the station. A release of 112 parasites was made at the U. S. Department of Agriculture Experiment Station at Canal Point in 1934, but no parasites emerged from a collection of mealybugs made here in 1936. Small releases of 12 and seven parasites, respectively, were made in 1936 on the U. S. Sugar Corporation fields at Clewiston and on the property of the Fellsmere Sugar Corporation at Fellsmere. No attempts have been made to determine whether the parasites are established at these two places.

Parasites sent to Puerto Rico.—In 1932 a shipment of 20 parasites was sent by T. E. Holloway by air mail from New Orleans to Geo. N. Wolcott in Puerto Rico. According to Wolcott (1936) the sugarcane mealybug parasite has not been recovered in Puerto Rico.

Distribution by the movement of seed cane.—In addition to the intentional releases at several points in the sugarcane area of three states, the parasite has been carried to several additional localities by the movement of seed cane infested with parasitized mealybugs. The movement of seed cane has been increasing for several years and will, most likely, continue to increase indefinitely on account of the large number of new varieties

being developed. It is not definitely known how widely the parasite has been distributed in this manner in the cane-growing states.

Some seed cane was carried from Houma for planting in variety tests that were conducted by the U. S. Bureau of Plant Industry in widely scattered sections of the sugarcane area of Louisiana. It has been definitely determined that colonies of the sugarcane mealybug parasite are established in or near the site of three of these variety tests. Parasites emerged from mealybugs that were collected from variety tests or nearby cane at Franklin, Jeanerette and Raceland, La.

Colonies of the sugarcane mealybug parasite were established on two farms located several miles from Cairo, Ga., by the transfer of seed cane from the U. S. Department of Agriculture Experiment Station. Another colony was found near Quitman, Ga., which is about 25 miles from Cairo. This colony probably came from the transfer of seed cane from the experiment station at Cairo. There has been considerable movement of cane in the Cairo section, and it is entirely possible that other colonies may have been thus established.

A colony was established at the Florida experiment station at Gainesville, Fla., by the transfer of seed cane from the Belle Glade station. Another colony was carried with seed cane from the federal experiment station at Canal Point to a farm near Okeechobee. Parasitized mealybugs were collected on the property of the U. S. Sugar Corporation about 2 miles from the nearest point of this seed planting. The cane planting was continuous from the point where parasites had been released to the place where the collection was made.

Resistance to low temperature.—A collection of mealybugs was made from standing cane in the field four days after the temperature dropped to 24° F. The mealybugs were examined frequently, and about 30 days later eight parasites emerged. Recoveries were also made the following summer after an unusually cold and damp winter. An outside temperature of 20° F did not seem to affect adult parasites that were confined in a tube by one thickness of thin cloth and placed near a north window of a frame laboratory building.

Extent of parasitization.—The mealybug infestation varied so much from one field to another and within the same field that it is very difficult to determine how effective the mealybug parasite is in the United States. It has been easily recovered during the last two years in the areas where the colonies were established in 1932.

Summary.—The Hawaiian sugarcane mealybug parasite was first liberated in the United States in 1932. The parasite was colonized in Louisiana, Georgia and Florida the first season. The colonies appear to be well established in all three states, since recoveries have been easily made several times. In addition to these liberations, the parasite has also been distributed by the movement of seed cane. It is very difficult to estimate how effective the parasite is in the control of the sugarcane mealybug, but it is undoubtedly of some value.—7-9-37.

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Experiments to Control Pecan Nut Casebearer in Texas, 1936

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The data included in this paper were obtained in 1936 from experiments in the control of the pecan nut casebearer, *Acrobasis caryae* Grote, conducted in two localities in the semiarid central and southwestern portions of Texas. The purpose of the experiments was to determine the value of one and two spray applications of lead arsenate in combination with zinc sulfate, and of nicotine sulfate plus summer oil and zinc sulfate, in the control of the first generation of this insect.

An effort was made to control the first generation of the nut case bearer by a single well-timed spray application, repeating similar experi-

Table 1.—Abundance and progress of hatching of first-generation eggs of the pecan nut casebearer collected at Brownwood, Tex., May and June 1936.

Date of Collection	Man-hours Required to Collect	Eggs						Nuts Infested by Nut Casebearer Larvae
		Newly Laid	Showing Red Spots	Shriveled*	Hatched	Parasitized by *Trichogramma*	Total	
May 12	2	0	0	0	0	0	0	0
May 15	4	18	8	0	0	0	26	0
May 16	2	23	14	0	3	0	40	0
May 22	2	20	30	61	5	4	120	0
May 25	2	34	29	74	48	15	200	19
May 30	?	51	20	93	85	12	261	76
May 31	?	19	20	72	74	0	185	Many
June 5	?	1	12	58	203	0	274	Many

* Shriveled eggs had apparently been attacked by predators.

ments conducted in 1935 in which good control seemed to be obtained although the infestation was so light that the results were not convincing. In order to obtain the greatest effectiveness from a single application, an effort was made to develop a more accurate method for timing the sprays.

The lead arsenate used was the ordinary commercial acid lead arsenate. The nicotine used was in the form of the sulfate, containing 40 per cent actual nicotine. Zinc sulfate was included primarily to control pecan rosette, and it also reduced the danger of arsenical injury.

Timing spray applications.—In the past, to determine the correct dates for spray applications, dependence has been placed largely upon the emergence of moths in the insectary. That indirect method is not entirely satisfactory for accurately defining the dates for effective spray

applications, and in 1936 eggs were collected and examined at frequent intervals to determine the proportion of hatched eggs in the orchard. Observations made to ascertain the abundance of the eggs will also indicate whether a light or heavy infestation of the nut casebearer is likely to occur, and afford a basis for a decision on the economic advisability of spraying for the control of this insect. The detailed results of the examination of eggs collected in one orchard at Brownwood, Tex., are given in table 1.

Table 2.—Results of experiments with lead arsenate and nicotine sulfate in the control of the nut casebearer on three varieties of pecans, Crystal City, Tex., 1936.*

No. Trees	Treatment	No. Nuts Examined	Per Cent Nuts Infested	Per Cent Control Due to Spraying
		Halbert		
23	Lead arsenate	5059	6.1	82. ±2.6
12	Nicotine sulfate	2432	4.8	85.8±2.
21	None	2277	33.9	
		Humble		
15	Lead arsenate	2738	10.1	86. ±1.7
4	Nicotine sulfate	1104	6.2	91.4±1.7
11	None	1025	71.9	
		W. Schley		
16	Lead arsenate	2419	9.8	74.2±5.1
4	Nicotine sulfate	404	3.5	90.8± .6
9	None	876	38.0	

* Lead arsenate was used throughout at the rate of 6 pounds per 100 gallons, with 2 pounds of zinc sulfate. Nicotine sulfate was used throughout at the rate of 12.8 fluid ounces per 100 gallons, with 3 quarts of summer-oil emulsion and 2 pounds of zinc sulfate.

Table 1 shows that a sufficient number of eggs had hatched by May 22 to justify spray applications and that few unhatched eggs were found in the orchard June 5.

Experiments at Crystal City, Tex.—In one orchard at Crystal City, Tex., 74 trees were sprayed and 41 trees were used as untreated checks. Each of the sprayed plots received one application on May 3. Records of moth emergence were used for timing the single spray application, which was made 3 to 6 days later than the optimum date. The effect of that application on the infestation of nuts by first-generation larvae of the nut casebearer is given in table 2.

Table 2 shows that on all three varieties nicotine with summer oil appeared more effective than lead arsenate in controlling the pecan nut casebearer. A considerable number of small larvae had entered the nuts shortly prior to the date of the spray applications, and the nicotine combination may have had a greater effect than lead arsenate on such larvae.

Experiments at Brownwood, Tex.—In one orchard at Brownwood, Tex., 89 trees were sprayed and 72 trees were used as untreated checks. The experiment was planned to compare the efficiency of one and two spray applications of the insecticides applied on different dates, and to determine the duration of the period in which effective spraying could be done to control the nut case bearer. Large numbers of eggs and nuts, table 1, were collected at frequent intervals to record the progressive

development of this insect throughout the period in which spray applications were made. The effectiveness of the spray applications on the infestation of nuts by the first-generation larvae of the pecan nut casebearer is given in table 3.

The data in table 3 show that satisfactory control of the pecan nut casebearer was obtained by a single spray application of 6 pounds of

Table 3.—Results of experiments with lead arsenate and nicotine sulfate on different schedules in control of the pecan nut casebearer, Brownwood, Tex., 1936.*

Variety of Pecan	No. Trees	No. Sprays	Dates of Applications	Treatment	No. Nuts Examined	Per Cent Nuts Infested	Per Cent Control Due to Spraying
				Plot No. 1			
Burkett	19	1	May 14	Lead arsenate	5083	1.6	95.3± .9
Burkett	13	2	May 18, June 1	Lead arsenate	3076	.2	99.4± .2
Burkett	9	2	May 18, June 1	Nicotine sulfate	2242	.6	98.2± .5
Burkett	42			None	7751	33.9	
Halbert	7	1	May 14	Lead arsenate	1848	2.8	84.7±4.5
Halbert	5			None	1063	18.3	
				Plot No. 2			
Burkett	7	2	May 18, June 1	Nicotine sulfate	1447	.8	96.4± .1
Burkett	6			None	1139	22.3	
				Plot No. 3			
Burkett	9	1	May 18	Lead arsenate	2546	.5	97.3±1.
Burkett	9	2	May 18, May 30	Lead arsenate	2793	.04	99.8±0.
Burkett	8			None	1400	18.5	
				Plot No. 4			
Texas Prolific	8	1	May 26	Nicotine sulfate	1838	1.1	94.8±1.8
Texas Prolific	5			None	1280	21.	
				Plot No. 5			
Squirrel's Delight	8	1	May 22	Lead arsenate	1319	4.	90. ±2.
Squirrel's Delight	6			None	1335	40.	

* Lead arsenate was used throughout at the rate of 6 pounds per 100 gallons, with 2 pounds of zinc sulfate. Nicotine sulfate was used throughout at the rate of 12.8 fluid ounces per 100 gallons, with 3 quarts of summer-oil emulsion and 2 pounds of zinc sulfate.

lead arsenate plus 2 pounds of zinc sulfate per 100 gallons, and also from 12.8 fluid ounces of nicotine sulfate and 3 quarts of summer oil plus 2 pounds of zinc sulfate in 100 gallons. Somewhat better and nearly perfect control was obtained by two applications of those insecticides. Field spraying tests showed that a single arsenical spray applied on various dates within the period May 14–22 resulted in good but not perfect control.

Summary.—Properly timed single spray applications of lead arsenate and of nicotine combinations resulted in good control of the larvae of the first generation of the pecan nut casebearer. Two applications of those insecticides effected nearly perfect control of this insect. Under semi-arid conditions no injury to pecan foliage resulted from the application of the insecticides discussed in this paper. A record of the hatching of first-generation eggs collected in the orchard at approximately biweekly intervals afforded a basis for accurately determining the dates for spray applications.—7-16-37.

ILLINOIS, on May 15, revoked the quarantine relating to the chestnut bark disease, having determined that such disease is now distributed in 20 counties in that state.

Tests on Comparative Effectiveness of Grasshopper Baits

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The grasshopper outbreak of 1936 was the first serious and widespread grasshopper infestation occurring in Oklahoma for approximately 10 years. At the beginning of this outbreak the recommended method of control was the use of the so-called "Kansas" or "Standard" bait.The bait was developed at the Kansas experiment station and gave such excellent results in that state in 1913 that it soon became the standard bait for grasshoppers throughout most of the United States. It consisted of 100 pounds of bran, 2 gallons of molasses, 2 dozen lemons or oranges, 5 pounds of Paris green or white arsenic, and a sufficient amount of water to moisten thoroughly. This formula was being recommended in Oklahoma until last year. The bait was thinly spread in the early morning. In recent years changes have been made in the formula, in some states at least, that have definitely cheapened it without materially reducing its effectiveness and in many places the time of day for distributing it has been changed, thus increasing its effectiveness. It was therefore considered worth while to conduct some work to determine if similar changes were practical to use under the conditions existing in Oklahoma.

One way in which the bait had been cheapened was by using a substitute or a diluent for the bran. Current conditions made such a change particularly desirable. The demand for bran to use in grasshopper baits soon drastically reduced the supply available and was accompanied by a sharp increase in price. In a few days the price rose from 80 cents to $1.25 per hundred and in many places bran could not be obtained at any price. It was at such a time that it was decided to start the work described in this paper.

M. G. Tucker, county agent at Altus, Okla., developed a formula using cotton-seed hulls and grey wheat shorts as the main ingredients instead of the bran, and with it he reported successful control. A series of field experiments was therefore planned to test out this formula as well as a number of others.

In the tests, each formula was compared with a standard formula very similar to the "Kansas" bait, except that 3 ounces of amyl acetate were used instead of two dozen citrus fruits. The change was made because some experiments not reported in this paper gave fairly conclusive evidence that there was but little if any difference in the attractiveness of baits containing these materials and it was more convenient to use the amyl acetate.

The data presented in this paper were taken July 1 to August 26, 1936, in the vicinity of Stillwater, Okla. The conditions existing at this time should be taken into consideration in evaluating the data. This period was one of the hottest and driest that has occurred here since weather records have been kept. Much of the time the soil was so hot that grasshoppers could remain on the ground but a short time and the majority

of them climbed as high as possible above the ground and sought shade. The predominating species of grasshoppers present were *Melanoplus differentialis*, *M. bivittatus* and *M. mexicanus*. *M. differentialis* was more abundant than all other species combined and the majority of them had reached the adult stage. It is therefore entirely possible that different results might have been obtained had the work been carried on while the hoppers were still in the nymphal stages and before the extreme drought conditions were reached. Also the great majority of the plots were in cotton fields where shade was comparatively abundant, which too may have had some effect upon the results obtained. The above, together with such factors as movements of grasshoppers into and within the plots, variations in temperature, wind and clouds, etc., prevent such data from being entirely accurate. When factors such as definite movements of the hoppers out of or into the plots were evident the data were not used in arriving at results.

One-acre plots were laid out in various crops where grasshopper infestations were as nearly uniform as possible. Fifteen pounds of the freshly prepared baits were scattered over these plots, usually in early morning, in such a manner that the standard mixture was spread in a plot adjoining those receiving the mixtures to be tested. Previous to the scattering of the baits, estimates were made as to the number of grasshoppers per square yard and the afternoon of the second or third day such estimates were again made, using the method suggested by Shotwell (1935) in making grasshopper surveys. In addition to this, counts were made as to the numbers of dead grasshoppers that could be found in a unit of area in each plot. In row crops, this unit of area was 100 feet of row including one-half of the space on each side of the row. Ten feet of row was counted at 10 places in each plot. In non-row crops such as alfalfa and pastures, wooden frames 2 feet square were thrown on the ground at random and the dead hoppers within counted. Approximately 50 such counts were made and the average number found per 4 square feet used as an indication of the relative numbers of grasshoppers killed by each bait. The formulas tested, the results obtained, and comparative costs are summarized in table 1 and illustrated in fig. 1.

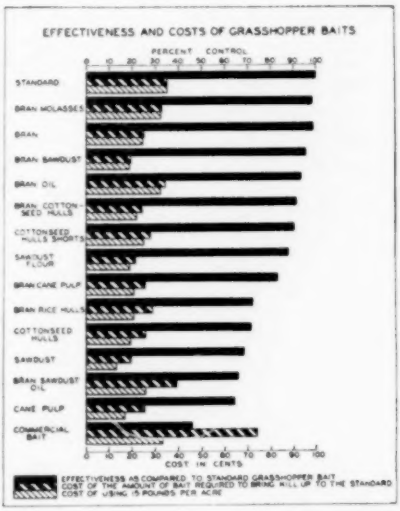
EFFECTIVENESS AND COSTS OF GRASSHOPPER BAITS
PERCENT CONTROL
0 10 20 30 40 50 60 70 80 90 100
STANDARD
BRAN MOLASSES
BRAN
BRAN SAWDUST
BRAN OIL
BRAN COTTONSEED HULLS
COTTONSEED HULLS SHORTS
SAWDUST FLOUR
BRAN CANE PULP
BRAN RICE HULLS
COTTONSEED HULLS
SAWDUST
BRAN SAWDUST OIL
CANE PULP
COMMERCIAL BAIT
0 10 20 30 40 50 60 70 80 90 100
COST IN CENTS
EFFECTIVENESS AS COMPARED TO STANDARD GRASSHOPPER BAIT
COST OF THE AMOUNT OF BAIT REQUIRED TO BRING KILL UP TO THE STANDARD
COST OF USING 15 POUNDS PER ACRE

Fig. 1.—Comparison of effectiveness and costs of various grasshopper baits, Stillwater, Okla., 1936.

Sodium arsenite (Na_2AsO_3) was used in each of the baits instead of white arsenic because other workers have sufficiently proved its effectiveness. It is cheap and more readily and evenly mixed. In determining

the average percentage of control both the estimated percentage of reduction of grasshopper infestation and the relative numbers of dead grasshoppers found were used. To illustrate let us assume that the estimated reductions of infestation on three plots were 90, 80 and 70 per cent, respectively, but the counts of dead grasshoppers were the same in each. Under these circumstances the highest estimate was scaled down, and the lower upward, with the result that 85, 80 and 75, respec-

Table 1.—Comparative effectiveness and costs of grasshopper baits, Stillwater, Okla., 1936.

Bait Formula	No. Plots	Av. Per Cent Control	Cost per Acre, Cents	Cost of Amt. of Bait to Bring Kill up to Standard, Cents	Rating in Effectiveness Compared to No. 1 as Standard
1. Bran 100 lbs., molasses 2 gals., amyl acetate 3 ozs., sodium arsenite 2 qts., water 10–12 gals.	52	71.5	35	35	100.
2. Bran 100 lbs., molasses 2 gals., sodium arsenite 2 qts., water 10–12 gals.	9	74	32	32.5	98.6
3. Bran 100 lbs., sodium arsenite 2 qts., water 10–12 gals.	9	74	25	25.4	98.6
4. Bran 50 lbs., sawdust 50 lbs., sodium arsenite 2 qts., water 10–12 gals.	11	68	19	19.9	95.7
5. Bran 100 lbs., sodium arsenite 2 qts., oil 2 gals.	3	70	32	34.3	93.3
6. Bran 50 lbs., cotton-seed hulls 50 lbs., sodium arsenite 2 qts., water 10–12 gals.	13	61	22	24.2	91.
7. Cotton-seed hulls 75 lbs., shorts 20 lbs., molasses 1 gal., sodium arsenite 2 qts., water 10–12 gals.	11	66	25	27.7	90.4
8. Sawdust 85 lbs., flour 15 lbs., sodium arsenite 2 qts., water 10–12 gals.	9	64	19	21.7	87.6
9. Bran 50 lbs., cane pulp 50 lbs., sodium arsenite 2 qts., water 10–12 gals.	4	58	21	25.6	82.1
10. Bran 50 lbs., rice hulls 50 lbs., sodium arsenite 2 qts., water 10–12 gals.	2	40	21	28.9	72.7
11. Cotton-seed hulls 100 lbs., sodium arsenite 2 qts., water 10–12 gals.	10	48	19	26.5	71.6
12. Sawdust 100 lbs., sodium arsenite 2 qts., water 10–12 gals.	11	48	13	19.2	67.6
13. Bran 50 lbs., sawdust 50 lbs., sodium arsenite 2 qts., oil 2 gals.	2	50	26	39.0	66.6
14. Cane pulp 100 lbs., sodium arsenite 2 qts., water 10–12 gals.	4	45	17	26.5	64.2
15. Commercial bait,* exact formula not known but consisting largely of rice hulls and molasses to which poison was added.	2	25	33	72.7	45.4

* This bait was tested because a local mill had prepared and sold considerable amounts of it.

tively, were the percentages of control used in arriving at the comparative value of the baits. The percentages of control in the early part of the work were somewhat higher than those later in the season. This explains the apparent discrepancies in column 2 of table 1 since some of the baits were tested at different times than others.

In calculating the cost per acre the prices used were as follows: bran $1 per hundred, black strap molasses 25 cents per gallon, amyl acetate 7 cents per ounce, sawdust 20 cents per hundred, sodium arsenite 30 cents per gallon, cotton-seed hulls 60 cents per hundred, shorts $1.50 per hundred, flour $2.75 per hundred, cane pulp 50 cents per hundred, rice hulls, 50 cents per hundred, lubricating oil 25 cents per gallon. These were the prices prevailing in Stillwater in 1936 when buying the ingredients in small quantities such as the average farmer would purchase. Fifty cents was added to the cost of the ingredients to cover the cost of mixing and spreading.

In figuring the additional cost of increasing the amount of bait necessary to bring its kill up to that of the standard, the cost per acre was increased by the proportionate amount that its control was less than that of the standard bait. For instance in bait No. 13 the control was 66.6 per cent of that of the standard bait, which indicates 33.4 per cent more bait spread over one-half greater area would kill approximately the same number of grasshoppers. Since the cost of this bait was 26 cents per acre, this figure should be increased by one-half or 13 cents. Thus 39 cents would be the estimated cost of increasing the amount of bait needed to bring the kill up to that of the standard. The same result is obtained by dividing the cost per acre by the relative percentage of control and multiplying the results by 100. It is recognized that such a figure is somewhat ambiguous, but it is believed this additional bait spread over 33.4 per cent more ground would kill approximately the same number of grasshoppers as the standard bait, and that also a larger grasshopper population would remain over all the area baited. If, however, the percentage of kill was sufficiently high to bring the grasshoppers under control, the bait costing the least to kill the same number of these insects might be the best bait to use. This would be particularly true where cost is a limiting factor, and it has been the writers' experience that such a condition is the rule rather than the exception. To illustrate let us assume that an individual feels he cannot afford to spread the bait over all his crops on account of the expense involved. He then should select the bait that will kill the largest number of grasshoppers for every dollar spent. Under such circumstances the cost of the amount of bait required to bring the kill up to standard should be given careful consideration.

The rating in effectiveness was obtained by giving a rating of 100 to the check (standard bait) plots and comparing the percentage of control of the adjoining test plots with that of the check. For instance, in bait No. 2 the average control was 74 per cent while adjoining check plots averaged 75 per cent control. Since 74 is 98.6 per cent of 75, the rating in effectiveness of bait No. 2 is 98.6.

It is interesting to note that the standard mixture gave the best kill of all the baits tried. However, the efficiency of the straight bran mixture (bait No. 3, table 1, fig. 1) so nearly equalled that of the standard, that it would not seem advisable to incur the additional expense of ingredients such as lemons and molasses. By adding these, the price was increased 25.7 per cent while the efficiency was increased by only 1.4 per cent. The bran–sawdust mixture (bait No. 4) was 95.7 per cent as efficient as the standard, and its cost was but 59.4 per cent as great. It should also be noted that its cost for killing the same number of grasshoppers as the standard mixture was the lowest of all mixtures used excepting the straight sawdust (bait No. 12), and was within a fraction of 1 cent per acre of the cost of the latter. Considering its high percentage of control and its low actual cost it appears that the half bran and half sawdust mixture was the most satisfactory of all the mixtures tried. In this connection it might be stated that the major portion of the 2000 tons of grasshopper bait used in Oklahoma in the summer of 1936 was this particular mixture and on the whole it gave very satisfactory results. The sawdust was added to the bran because the amount of bran available

was limited and it was desired to make this amount go far as possible. The practical results obtained over the state as a whole bear out the conclusions drawn from the experimental data.

The baits containing cotton-seed hulls (Nos. 7 and 11) are of much interest. It is true that their effectiveness was less than that of a number of other baits used, but it is possible that this was due in a large measure to the size of the individual particles of the cotton seed hulls. Observations show that a grasshopper in feeding upon bran picks up the individual flakes and so manipulates them with its mouthparts that small particles are readily bitten off and swallowed. In the case of ordinary cotton-seed hulls, most of the particles are too large to be handled in such a manner by the grasshopper, which may account for the lower kills obtained by cotton-seed hull baits. It is planned to conduct further tests using hulls that have been ground to the approximate consistency of wheat bran. Some of the qualities of properly prepared cotton-seed hulls may particularly adapt them to grasshopper baits. The small amount of lint adhering to the hulls may be useful when powdered arsenic is used by causing it to adhere better to each particle. The lint also may make it possible to use more water in the bait, thus keeping it moist over a longer period, and many workers believe water is the most attractive part of any bait. At any rate its lower cost and the quantities available in Oklahoma render it worthy of thorough investigation.

The effectiveness of the straight sawdust bait (No. 12) was low but its economy makes it attractive in many cases. Although the number of tests on rice hulls and cane-pulp baits (Nos. 10 and 14) was too small to permit the drawing of conclusions; they did not show sufficient promise to justify further trials. The "commercial bait" (No. 15), which was prepared largely from rice hulls and molasses, gave the poorest results of any of the mixtures tried. It was too lumpy and sticky to permit the poison to be mixed thoroughly and for the same reason it was next to impossible to scatter it properly. The cost of the amount required to bring its kill up to that of the standard mixture was so high that its use by farmers should not be recommended under any circumstances.—7-14-37.

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The 1936 Grasshopper Outbreak in Oklahoma

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Grasshoppers have always been a problem locally in Oklahoma. There are farms in some counties every year where control measures are necessary. Records of serious state-wide outbreaks, however, are few and far between. It is generally known that these pests were serious over large parts of the state in 1924 and that in 1925 the trouble continued but

was not so acute nor widespread. It is difficult to compare the seriousness and intensity of the 1936 outbreak with that of 1924–25. People in the southwestern part of the state believe that it was no worse. In the northern part, however, it is generally agreed these insects were far more numerous and destructive than at any time since statehood.

Probably nobody will ever be certain nor agree as to what were the causes for this tremendous increase in the grasshopper population. Those who have studied the grasshopper situation in Oklahoma for a number of years believe the great reduction in the number of parasitic sarcophagid flies removed a very important natural check. But what conditions caused the scarcity of these flies? Certainly the climatic conditions in 1936 were very unfavorable for the development of this fly, the resting stage of which is spent a few inches deep in the soil. Soil temperatures must have been much too high for the survival of many of the fly puparia. Since grasshoppers are also insects that thrive in dry weather, it is possible that the upward trend in the grasshopper population may have started during the drought of 1934.

There were at least four species which caused most of the trouble, namely *Melanoplus differentialis*, *M. mexicanus*, *M. bivittatus* and *Dissosteira longipennis*. The first three were prevalent over the greater part of the infested area with the differential locust predominating by far and the lesser migratory locust (*mexicanus*) being next in abundance. The so-called long-winged locust of the plains, *D. longipennis*, was confined largely to the panhandle section of the state. It appeared in flying swarms there in mid-August and the hoppers remained more or less active until late October. Some excitement was caused by a night flight of grasshoppers in June. This species, *Xanthippus corallipes pantherinus*, is attracted to lights and apparently a migratory flight took place at night over a fairly large area of the state. The insects were attracted to the downtown lights at night. At no time were they very numerous in the fields.

Area in state involved.—Most of the state was involved in the outbreak except the southeastern part and the three panhandle counties. Even in the latter section the long-winged plains locust caused considerable damage. While a large number of counties were infested, the more serious outbreaks were usually confined to certain sections of each county. In other words the infestation was "spotted." In some parts, particularly the northern and eastern counties, the infestation was more serious in the farms bordering creeks, but this was not always true. In the southwestern part of the state the heaviest infested sections were often on the higher more rolling land. It was evident, however, that alfalfa was the most important crop which served as a breeding ground for these insects. Pastures were also important. Farm after farm was visited where it was plainly evident that the grasshoppers had migrated to the small grains and row crops from pastures and alfalfa.

Economic losses.—The total losses to different crops in the state exceeded seven million dollars of which the largest, a loss of three million dollars, was caused to the cotton crop. Corn suffered an estimated loss of $1\frac{1}{2}$ millions; small grains, chiefly oats, $1\frac{1}{5}$ millions. As is so often true it has been impossible in many cases to evaluate losses chargeable to

the grasshoppers and to drought since these very often occur together.

History of the outbreak.—Reports of grasshopper damage to crops, especially alfalfa, began to filter into the entomology office in the fall of 1935 and then again early in 1936. On May 23, a visit to a ranch in Osage county revealed grasshoppers to be swarming in the pastures, open woodlands and alfalfa fields. They were mostly in the nymphal stage. In June they began migrating from pastures and alfalfa to small grains, cotton and corn. Where the infestation was unusually heavy in alfalfa they never gave it a chance to grow, cutting off the tender growth as fast as it appeared. Plants were killed along the margins of the fields, often for considerable distances toward the center. Sometimes there were not enough hoppers to prevent growth or there was a migration from fence rows. In such cases the alfalfa grew to about cutting stage and was then stripped. The small grains did not hold the grasshoppers long. With their harvest these insects were driven out and the concentration on row crops was greatly increased. Corn was full grown and the ears were filling out. In many cases this crop was beginning to suffer from the dry weather. The grasshoppers invaded the fields from the nearest point and usually left nothing but the central stalk. Cotton plants were cut down from the margins, the grasshoppers working towards the centers of the fields. Sometimes there was a general dispersal over the entire field. As the plants were mostly small, a few hoppers caused a large amount of damage.

By late July the temperatures were becoming so excessively high that the grasshoppers began moving to the trees along the creek banks to escape the intense heat. Previous to this time roosting in trees and on fence posts was general during the heat of the day. Thousands of trees were stripped of their foliage, particularly in the southwestern part of the state. Chinaberry and mulberry were particularly favored, as was sumac. In mid-August swarms of the long-winged plains locust appeared in the panhandle. These could be seen flying with the wind from the desert areas. While poisoning operations over much of Oklahoma were at a standstill, considerable bait was broadcast in Texas and Cimarron counties to control this species.

A survey was made during August in representative counties in the north central, northeastern and southwestern sections of the state to estimate the adult grasshopper population. As a result of this survey it was found that these insects had largely disappeared in the southwestern and northeastern counties which were surveyed; especially in the latter section. This was largely due to starvation caused by the drying up of vegetation. In the north central part, however, there were still many grasshoppers present. During this survey no grasshoppers were observed ovipositing, although a few *differentialis* were observed pairing. Dissection of a number of grasshoppers showed only a few were gravid.

On September 15, rains had fallen in some sections and it had been raining in others for a somewhat longer period. The grasshoppers were still largely distributed in trees and shrubbery along creek bottoms. In some sections dissection showed no eggs present in the females but in others eggs were fairly well developed. Some oviposition was observed, and the insects were beginning to migrate back to the alfalfa and wheat

fields. By early October oviposition was taking place rather generally and by November 19 most of the insects had died and oviposition was practically completed.

The campaign for control.—As soon as it was evident that a statewide outbreak was threatening and that federal aid was possible, a grasshopper control committee was appointed. The membership included the extension entomologist, the director of the extension service and the experiment station entomologist. The purpose of this committee was to serve as a general clearing house for information relative to control, and to plan, direct and coordinate the state work in cooperation with the U.S.D.A. Two men assisted C. F. Stiles, extension entomologist, in the field, and in addition the experiment station staff assisted for a limited time in some of the organization meetings.

The county was selected as a natural unit for control operations and the county agent was placed in charge. He was assisted by county grasshopper control committees. These were organized in 71 of the 77 counties of Oklahoma, although actual control work was undertaken in only 60 counties. The county committee consisted of the county agent and two assistants who in many instances were business men or farmers who could devote a large part of their time to grasshopper control work.

At the start it was found that there would be insufficient poison and bran supplied by the federal government to cope with the situation. It was therefore decided, with federal approval, to allow diluting the bran with an equal amount of sawdust. The formula used was 100 pounds of bran (or equal amounts of bran and sawdust mixed), 2 quarts of sodium arsenite and enough water to make a moist but crumbly mash. Since sawdust was scarce in the southwestern part of the state permission was secured to substitute cotton-seed hulls for the sawdust for mixing with the bran after it was found by field tests that such a mixture was effective.

Each county agent set up from one to several mixing stations in his county and organized his mixing crew. Location of these stations varied from empty warehouses to cotton gins. Each mixing station had its foreman, who was often a vocational agricultural teacher, a man hired by the county commissioners or one of the CCC boys. Farmers desiring poison brought their bran or sawdust and it was then mixed and resacked.

Before federal funds were available the county commissioners in at least 10 counties had set up revolving funds or had purchased some material. Approximately $1,000 was appropriated. It is impossible to get any estimate as to the amount of private funds used, but this was undoubtedly very large in some counties. Approximately 20 tons of crude white arsenic were purchased. Thus it is known that around 400 tons of bait were prepared prior to government aid at an estimated value of $18,400. The total amount of federal bran used in the state was about 800 tons, which is sufficient to prepare 1600 tons of dry material mixed for bait when matched with an equal amount of sawdust or bran.

The federal government shipped 10 cars containing 31,000 gallons of sodium arsenite and 51 cars containing 1235 tons of bran into Oklahoma to combat the grasshoppers. It is estimated that the value of the crops saved by the use of the bait was around one million dollars. To this must be added the great educational value of the campaign.—7-14-37.

CURRENT CONTRIBUTIONS

Leafhopper Injury to Potato Foliage

And Its Relation to Tuber Yields

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Injury caused by the potato leafhopper, *Empoasca fabae* Harris, to potato foliage in the eastern half of the United States has become well known since Ball (1919) called attention to the potato leafhopper as the cause of hopper burn. The injury comes from the leafhopper feeding punctures which plug (Smith 1933, Smith & Poos 1931) or otherwise disrupt (Johnson 1934) the vascular tissue of the leaf and stem, thereby interfering with the movement of food and water. The first symptom of hopperburn (Fenton & Hartzell 1923, Parrott & Olmstead 1920) on potato is the appearance of a triangular yellowish spot at the tip of the leaf which gradually turns brown. Similar triangles may also appear at the end of each side vein of the leaf, or in the case of old or heavy infestations

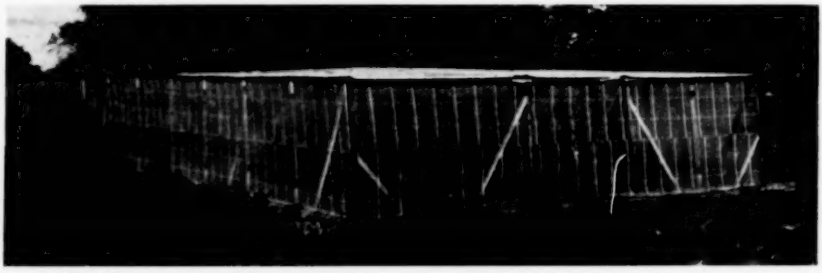

Fig. 1.—Field cages covering potatoes.

the entire margin of the leaf may roll upwards and turn brown. The older leaves below the growing tip become hopperburned first but finally the entire plant is injured or killed before normal development of potato tubers has been completed. Correlation of this leaf injury with the resulting losses in tuber yield is greatly complicated in the field by simultaneous presence of many potato insects and diseases.

This paper reports on results obtained when potatoes were grown in field cages with and without potato leafhoppers in the absence of other foliage insects. Data are presented which indicate that control of the potato leafhopper with Bordeaux mixture is the result of a complex series of reactions. All experiments reported were conducted on mineral upland soils in western New York.

Injury to potato foliage in cages.—During a three-year period, 1934 to 1936, experiments were conducted to determine the amount of injury caused by *E. fabae* to Smooth Rural potatoes grown in field cages, fig. 1, covered with tobacco cloth. The tobacco cloth was placed on the cages early in June, immediately after the potatoes were planted, and was not removed until the vines were frozen in October. Each cage was 6 feet

high and covered an area of 625 square feet which, under the conditions of the experiments, allowed for 160 potato plants in each cage. The plots within the cages were arbitrarily set by dividing the total area in half by small colored flags indicating different treatments as illustrated in fig. 2.

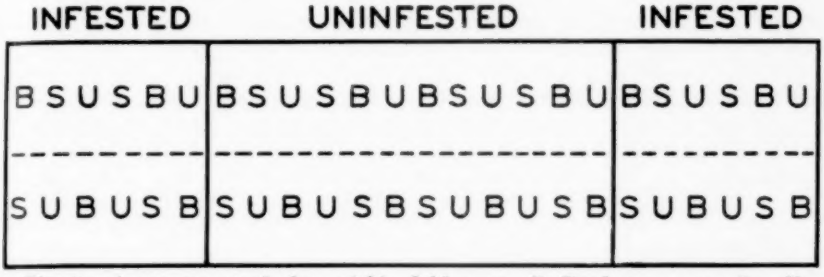

Fig. 2.—Arrangement of plots within field cages. *B*, Bordeaux spray; *S*, sulfur dust; *U*, unsprayed.

When the vines were about 6 inches high adult potato leafhoppers were captured in neighboring potato fields and introduced into two cages while one other cage of double length placed between the two infested cages remained uninfested, fig. 2. The leafhopper population in the infested cages was maintained at approximately the same population level as occurred naturally in adjacent potato fields. To obtain an even distribution of leafhoppers within the cage, the insects were introduced before the different treatments were started. When cool wet weather prevailed in late fall, the aphid *Myzus persicae* (Sulzer) was usually also found in all cages. The winged migrants were blown against the cage and some of the insects invariably were able to enter through the tobacco cloth. Since this insect never became numerous until very late in the season

Table 1.—Effects of potato leafhoppers and insecticides used to control them on yields* of Smooth Rural potatoes grown in cages.

Treatment	1935 and 1936			1934 to 1936		
	Hoppers† per Leaf	No. Tubers	Lbs. Net Weight	Hoppers† per Leaf	No. Tubers	Lbs. Net Weight
			Infested Cages			
None	3.5	36.6	6.92	3.1	33.7	6.88
Bordeaux mixture 4:2:50	1.2	38.5	8.39	1.2	35.3	8.2
Sulfur dust 300-mesh	.7	42.5	9.05		*not used*	
			Uninfested Cages			
None	0	44.4	9.93	0	41.7	10.14
Bordeaux mixture 4:2:50	0	44.	10.4	0	39.9	10.45
Sulfur dust 300-mesh	0	47.5	10.43		*not used*	
Significant difference between means, odds 21:1		4.85	1.12		5.24	1.08

* Yields are given on a 10-plant basis. † Adults and nymphs at height of infestations.

no attempt was made to control it. Counts made in September showed that the aphid was dispersed throughout both the infested and uninfested cages in the following way: sulfur dusted vines least, untreated approximately twice as many and Bordeaux-sprayed plants three times as many as on the sulfur-dusted plants.

Treatments were started the latter part of July and the last of five applications was applied in early September. The bordeaux mixture (4:2:50) was applied by means of a bucket sprayer at the rate of nearly 200 gallons to the acre for each application. A rotary hand duster was used to apply the sulfur (300 mesh) at the rate of 60 to 70 pounds per acre per application. The materials were always applied on the same day and care was taken to prevent drifting of the dust or spray.

Yield data were obtained by counting and weighing the tubers from each row plot. To render intercomparisons easier the data were placed on a 10-plant basis. The variance method (Snedecor 1934) of statistical analysis was used to determine the confidence which might be placed in the results.

Table 2.—Reactions of leafhopper nymphs to potato leaflets sprayed with Bordeaux mixture.

Treatment on One Leaflet of Twin Leaflets	No. Nymphs Used	Percentage of Nymphs on Untreated Leaflet on Different Days after Spray Was Applied					
		1	2	3	4	5	Average
Top of one leaflet sprayed	190	42	49	50	50	47	48
Bottom of one leaflet sprayed	126	64	68	68	66	78	69
Top and bottom of one leaflet sprayed	359	73	76	75	80	79	77

The results obtained during the three-year period from 1934 to 1936 inclusive are shown in table 1. Plants in uninfested cages always gave larger yields than those in the infested cages and within the infested cages the lowest yields in both number and total weight of tubers were obtained from the plants which had the largest number of leafhoppers feeding on them. Although both Bordeaux spray and sulfur dust treatments reduced the leafhopper populations and thus increased tuber yields, injury was not completely prevented by either treatment. In cages without leafhoppers significant differences in yields between treatments were never obtained. The small differences noted in table 1 were probably due to chance.

Unfortunately the leafhopper populations were counted late in the season only so that the figures given in table 1 are really averages at the height of the infestations. Counts, which included both nymphs and adults, were made on large, nearly mature leaves located about midway on the potato stalk. It is of considerable interest to note that the occurrence of leafhoppers on Bordeaux-sprayed and unsprayed plants in the cages was approximately the same as occurred in open potato fields. For example, sweepings of potato foliage over a period of several years indicated that there were about twice as many leafhopper adults on the untreated as there were on Bordeaux-sprayed plants. Similarly nymphs were more numerous on untreated plants, the ratio depending on the treatments which the plants received.

Leafhopper injury to the foliage of the potato plant reduced the size and decreased the total numbers of tubers retained by the plant. Similar

results were obtained in large local muckland fields of Irish Cobbler potatoes where the differences in yields between the treated and untreated plants were due to differences in size and number of tubers. To determine the effect of the cage on the results obtained, the same variety of potato (Smooth Rural) was planted in adjoining ground and treated similarly to the caged plants. The Bordeaux-sprayed, uncaged plants, exposed to all insects, yielded an average of 10.6 pounds of tubers on a 10-plant

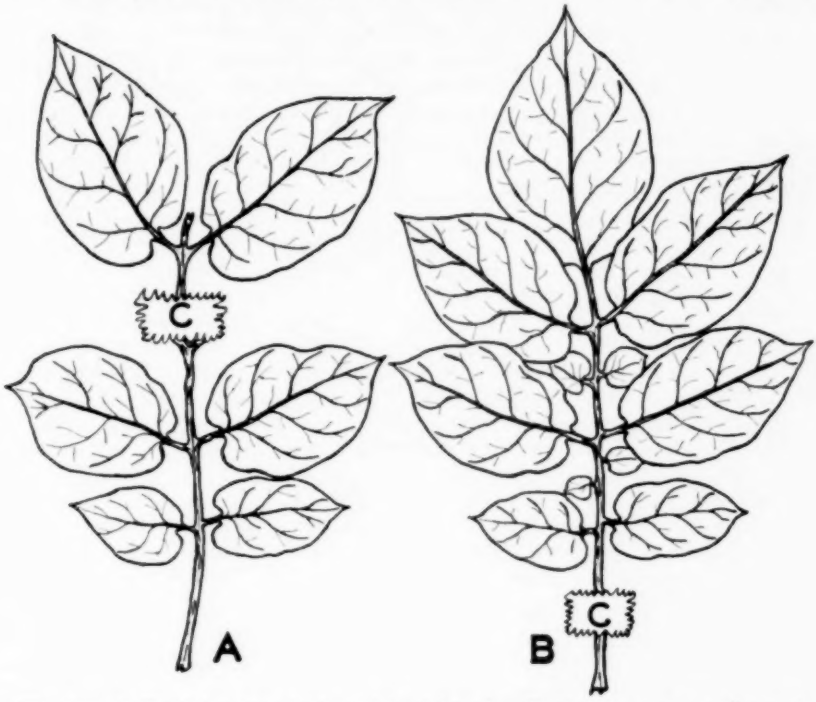

Fig. 3.—*A*, Partial potato leaf used to determine Bordeaux spray repellency to leafhopper nymphs. *B*, complete potato leaf used in determining Bordeaux spray repellency to adults and its toxicity to nymphs. *C*, loose band of cotton fibers to prevent migration.

basis or 1.1 pounds more than the untreated, uncaged plants. Where the Bordeaux mixture was applied to the ground around the plant instead of on the foliage no increase in yield was obtained over the untreated.

Repellency of Bordeaux to potato leafhopper.—Although primarily a fungicide, Bordeaux mixture has been used as a repellent (Metcalf & Flint 1928) for many insects. Recently, however, DeLong and his students (DeLong 1929, DeLong, Reid & Darley 1930) questioned the repellent action of Bordeaux to the potato leafhopper and advanced the theory that Bordeaux acts as a stomach poison to the leafhoppers. Fenton & Hartzell (1923) had previously shown that Bordeaux-sprayed leaves were highly toxic to nymphs but not appreciably toxic to the leafhopper adults. To determine whether or not Bordeaux mixture was

repellent, a series of potato leaves on plants were arranged as is shown in fig. 3, *A*, with a loose band, *C*, of cotton fibers to prevent migration of the nymphs. One of the twin terminal leaflets was sprayed three times with Bordeaux mixture during a period of about 10 days and the other leaflet remained untreated. After the third spray was completely dry, five or more second-instar leafhopper nymphs were introduced on the sprayed leaflet and left until next day to distribute themselves on the two leaflets. The number of nymphs on sprayed and unsprayed leaflets were then counted daily for about a week, with the results shown in table 2.

Bordeaux mixture was markedly repellent when applied on the underside of the leaf but did not appear to have any effect when applied to the top surface of the leaf. This repellency was not due to increased mortality on the sprayed leaflet, since the number of nymphs on the leaflets did not decrease significantly for about four days. The repellency did not decrease for about five days and some effect was evident for more than 10 days.

Table 3.—Populations of potato leafhoppers on isolated, unsprayed and Bordeaux-sprayed leaves, one month after the last spray application.

Treatment	Population of 30 Leaves		
	Nymphs	Adults	Total
Untreated	26	8	34
Sprayed, top surface only	27	13	40
Sprayed, both surfaces	10	2	12

A number of entire potato leaves on different plants were sprayed three times as previously described and banded with cotton fibers as shown in fig. 3, *B*. One month after the date of the last spray application the leafhopper populations were determined with the results shown in table 3. Since the leaves were isolated from other potato leaves and banded to prevent migration from other parts of the plant, the nymphs found were considered to be an indication of the repellency of Bordeaux spray to the ovipositing female. The results indicate that the Bordeaux spray applied to both surfaces of the leaves was effective in repelling the female, while leaves sprayed on the top surface only were equivalent in infestations to unsprayed leaves.

Toxicity of Bordeaux to potato leafhopper.—Bordeaux mixture was shown to be a repellent but this did not preclude the possible toxic action of sprayed leaves to the leafhopper. To study this point further, entire potato leaves, fig. 3, *B*, were caged with known numbers of first and second-instar nymphs. After 15 to 20 days the leaves were cut from the plants and the entire cages were fumigated in a closed can with nicotine until all insects were dead. The leaves were then removed from the cages and the insects examined and counted. A summary of results obtained in 1935 and 1936 is given in table 4.

Table 4.—Mortality of potato leafhopper nymphs on caged potato leaves sprayed with Bordeaux mixture.

Treatment	No. Nymphs Used	No. Reaching Adult Stage	Per Cent Reaching Adult Stage
Untreated	203	101	50
Sprayed leaves* (top surface only)	186	55	30
Sprayed leaves* (bottom surface only)	115	1	1
Sprayed leaves* (both surfaces)	201	2	1

* The leaves were sprayed three times, the last application just before the leafhoppers were added.

It is shown in table 4 that the mortality of the leafhopper nymphs on unsprayed leaves was comparatively high (50 per cent). Mortality increased slightly when

the leaves were sprayed with Bordeaux on the upper surface. The spray was most toxic when applied to the lower surface of potato leaves and this toxicity was not increased when both leaf surfaces were sprayed.

In the field, both the repellency and the toxicity of Bordeaux-sprayed foliage act to reduce leafhopper populations.

Summary.—The Smooth Rural variety of potatoes were grown in large field cages with and without the potato leafhopper, *Empoasca fabae* Harris. In the absence of leafhoppers sulfur dust and Bordeaux spray applied to the foliage failed to give increases in tuber yields over untreated plants. In the presence of leafhoppers, however, both treatments reduced leafhopper populations and resulted in increases in yields over the untreated plants. Treated plants in uninfested cages always produced larger tuber yields than plants receiving the same treatments in leafhopper-infested cages. Leafhopper foliage injury was directly correlated with a decrease in numbers and size of the resultant tubers.

Bordeaux spray applied to the upper side only of potato leaves was but slightly toxic to nymphs and did not repel potato leafhoppers. When the spray was applied to the underside or both sides of leaves it was both highly toxic and repellent to the nymphs and it also repelled the leafhopper adults.—4-22-37.

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Spray Residue Removal from Cherries

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In 1935 a few late shipments of New Jersey sour cherries were reported to have contained more lead residue than the legal tolerance. From limited

[1] Journal series paper of the New Jersey Agricultural Experiment Station, department of spray residue investigations.

data obtained and observations made at that time it was thought that in most cases the excess residue was due to drift of spray material from adjoining apple orchards. Therefore it was decided to make a comprehensive spray residue survey of the 1936 crop of sour cherries.

Table 1.—Spray residue on New Jersey sour cherries, 1936.

Orchard No.	Location of Sample	Treatment of Sample	Gr. per Lb. As_2O_3	Gr. per Lb. Lead	Dates of Lead Arsenate Spray	Date Sampled	Remarks
1	Inside*	None	.011	.023	May 12	June 9	
1	Outside*	None	.023	.051	May 12	June 9	
2	Inside	None	.004	.018	May 10	June 12	
2	Outside	None	.032	.074	May 10	June 12	Apples sprayed on June 11 with wind blowing toward cherry trees
3	Inside	None	.005	.018	May 9	June 9	
3	Outside	None	.045	.122	May 9	June 9	Apples sprayed on June 9
3	Outside	Washed†	Trace	.004	May 9	June 9	
4	Inside	None	.004	.018	May 9	June 9	
5	Inside	None	.009	.032	May 9, 19	June 9	
6	Inside	None	.011	.042	May 7, 17	June 11	
6	Inside	Washed†	Trace	Trace	May 7, 17	June 11	
6	Inside	Washed‡	Trace	.003	May 7, 17	June 11	
7	Inside	None	.013	.036	May 10, 20	June 9	
7	Inside	None	.009	.042	May 10, 20	June 12	Rain on June 11, 12
7	Inside	Washed†	.001	.004	May 10, 20	June 9	
7	Inside	None	.006	.032	May 10, 20	June 9	Rain on June 11, 12, 17, 18
8	Inside	None	.054	.131	May 9, 18, 28	June 9	Sprayed with water on June 8
8	Inside	None	.06	.15	May 9, 18, 28	June 9	
8	Outside	None	.084	.244	May 9, 18, 28	June 9	
8	Inside	None	.019	.103	May 9, 18, 28	June 12	Rain on June 11, 12
8	Inside	Washed†	.001	.004	May 9, 18, 28	June 9	
9	Inside	None	.018	.065	May 13, 23	June 9	
9	Inside	None	.013	.046	May 13, 23	June 12	Rain on June 11, 12
9	Inside	None	.003	.018	May 13, 23	June 17	Rain on June 11, 12

* The term "inside" indicates that sample was taken from trees at least four rows removed from apple trees that received late spray applications; "outside" indicates that sample was taken from the row next to the late-sprayed trees.

† Washed in 1 per cent HCl for 30 seconds.

‡ Washed in .25 per cent HCl for two minutes.

At the outset of this survey it was expected that no appreciable amount of spray residue would be found, except under special conditions. The results in table 1 show that this was not the case. During the period between the first lead arsenate spray and the beginning of the harvest period there was an exceedingly light rainfall. This would cause a higher residue than one would expect, for two reasons: (1) very little wash-off of residue, and (2) smaller size of the cherries because of drouth conditions. The results given in table 1 show that where only the "shuck split" spray was applied at the proper time, as in orchards 1, 2 and 3, spray residues were not in excess of legal tolerances, except in the first row and in some cases in the first three rows adjoining an apple orchard. The high residue on these few rows was due to the drift of the spray materials when the apples were sprayed. If more than the "shuck split" spray was applied, the residues were above the federal tolerances. The exception

to this was the cherries from orchard No. 9 after heavy rains had removed a part of the residue. Although orchard No. 7 had more rain than orchard No. 9, residues were not reduced in the former as much as in the latter. The explanation for this is that the spray applied in orchard No. 7 contained a casein spreader and sticker, whereas that applied in orchard No. 9 contained neither. Furthermore, the spray and harvest dates were earlier in orchard No. 7. The cherries of this orchard were harvested between June 10 and 19, and in orchard No. 9 the harvest was not begun until June 19. This late harvest allowed a rapid increase in size, which caused considerable decrease in grains of residue per pound of fruit.

The survey showed that approximately 75 per cent of the commercial sour cherry crop of New Jersey contained more than the allowable tolerance for both lead and arsenic spray residues. Because of these conditions some method had to be devised, without delay, to remove the excess.

Since growers have found by experience that sour cherries cannot be picked or handled while wet, any method of spray residue removal requires that the cherries must not be handled except in packed form.

After much experimentation, a successful and practical method to remove the excess spray residues was devised. Preliminary notice of this investigation was published in New Jersey State Horticultural Society News **17**: 834, 1936. The spray residues were removed in a solution of 1 per cent by weight of hydrochloric acid in the following manner:

The cherries were harvested and placed in the packages in which they were to be marketed. The package as a rule was either a climax basket or a 32-quart-basket crate. The container was dipped into a tank or barrel containing the acid solution for a period of 30 to 60 seconds. Slow agitation of the container facilitated removal of the lead and arsenic residues. After removal from the acid, the fruit was allowed to drain for a short time. This was followed by two water rinses carried out in a manner similar to the procedure followed with the acid solution but for shorter periods.

This general method was used in all cases except on the cherries of orchard No. 6, where slight modifications were made to suit local working conditions. These cherries were sprayed on May 28 with 16 pounds of lime plus 6 pounds of bentonite–sulfur per 100 gallons of water. The cherries were packed in crates. The crates were placed in hydrochloric acid (.25 per cent by weight) for two to three minutes and then rinsed thoroughly.

This washing process removed the bentonite–sulfur residues satisfactorily. In other orchards where less than 10 pounds of lime per 100 gallons of water was used with bentonite–sulfur, difficulty was encountered in removing the latter. In all cases arsenic and lead residues were readily removed.

The washed cherries had a better market appearance, but were also as good in keeping qualities as the unwashed fruit.

As in the case of apples, the cherries presented a brighter appearance when .1 per cent of the wetting agent *Vatsol* was added to the acid wash solution, thereby further enhancing the marketability of the fruit.—1-21-37.

Oblique-banded Leaf Roller, a Dewberry Pest in Utah

GEORGE F. KNOWLTON AND MERLIN W. ALLEN, *Utah Agricultural Experiment Station, Logan*

Tiny lepidopterous caterpillars have been infesting both ripe and green dewberry fruits in several northern Utah localities. Such damage has been observed by farmers at Granite and Butlerville since 1929, and possibly it occurred earlier. Damage was severe in the latter localities during the summer of 1932, late berries, in some cases, being refused upon the Salt Lake City market. Pickers noticed the very small caterpillars crawling over freshly picked berries in the cups, and housewives were shocked to see such worms floating to the top when the berries were placed in water to be washed. Infested berries usually can be recognized in the berry patch by the presence of one or more shriveled drupelets, and by the slight webbing present around the point of entrance, principally under the calyx, where the larvae most frequently occur.

Distribution in Utah.—Injury to dewberry fruits has been observed to occur in Utah at Granite and Butlerville in Salt Lake county, south of Pleasant Grove and at Lindon in Utah county, and south of Willard in Boxelder county. In addition, moths of the oblique-banded leaf roller, *Cacoecia rosaceana* (Harris), have been collected at Bountiful, Circleville, Farmington, Logan Canyon, Perry, Provo and Tooele, indicating that this species may occur rather generally over cultivated areas of northern Utah.

Eggs.—Moths confined in small cylindrical cages began ovipositing June 28, 1936, and continued until July 15. In the field egg masses were deposited upon the top of leaves of dewberry, ground cherry, wild lettuce and *Amaranthus*, the oval masses usually lying along the midrib or over one of the larger accessory veins. Each egg mass consisted of 46 to 279 eggs, covered by a tough translucent protecting material of a gelatinous nature. Individual moths laid from 240 to approximately 900 eggs each. Individual eggs were approximately 1 mm. long, .6 mm. wide and .2 to .3 mm. thick. In a mass, fig. 1, E, the individual eggs overlap each other, somewhat resembling fish scales. The incubation period varied from eight to 13 days, the average being 10.5 days. Newly laid eggs were light yellow, but soon became darker yellow with pink spots. The dark head and thorax of the maturing embryo was visible through the semitransparent covering of the egg mass. Upon hatching the larvae slowly emerged head foremost from holes they had made through the wall of the egg and the protective covering of the egg mass, usually requiring several minutes for complete emergence. During 1936 the first larvae hatched on July 1, and hatching continued until July 20.

Larvae.—As soon as the larvae were hatched they began crawling over the leaves and stems of the dewberry plant in search of a suitable place to feed. One newly emerged larva was observed to crawl 20 inches in one hour. In the course of this distance several leaflets and petioles were visited. Each individual under observation settled down to feed upon either a leaflet or a fruit. Larvae which attacked fruit usually

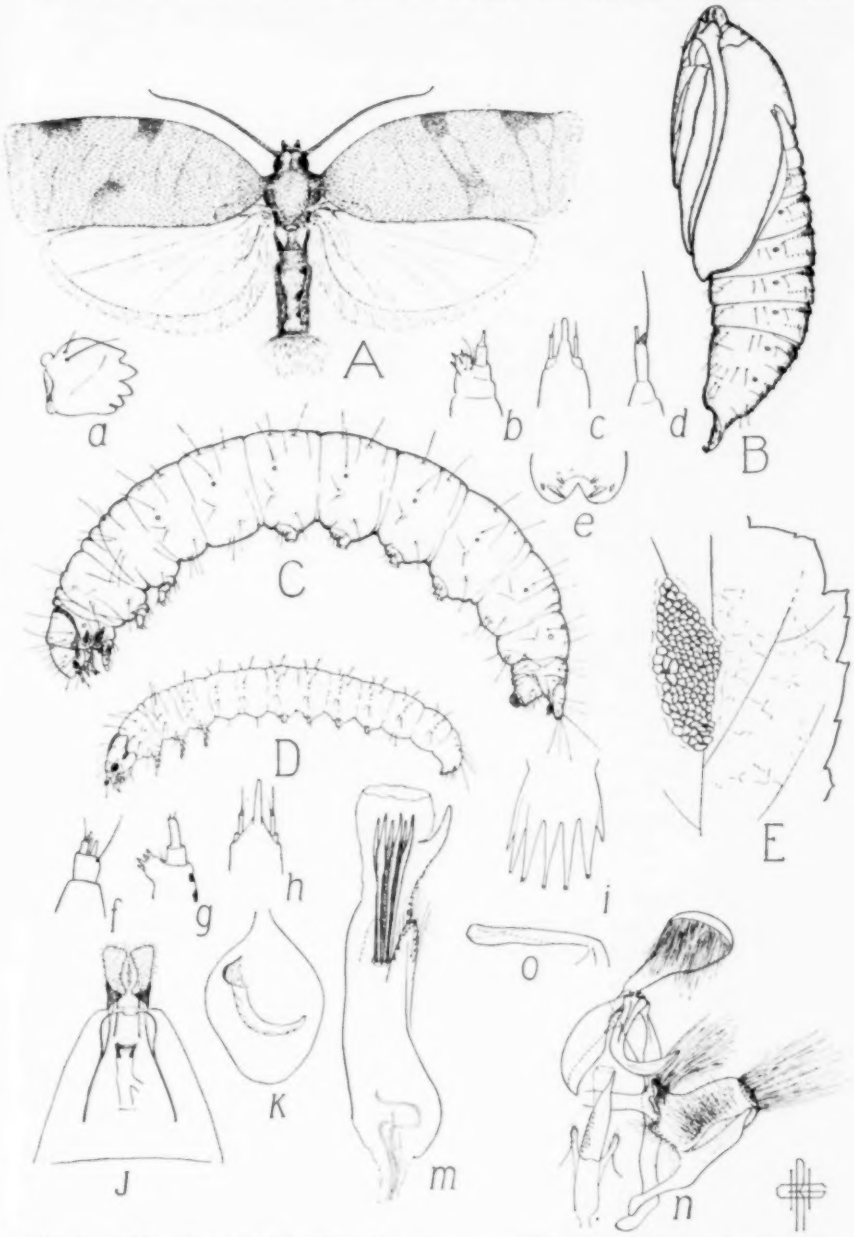

Fig. 1.—Oblique-banded leaf roller, *Cacoecia rosaceana* (Harris). *A*, adult male; *B*, pupa; *C*, mature larva; *D*, immature larva; *E*, egg mass. Mature larva (*C*): *a*, left mandible; *b*, right maxilla; *c*, labium; *d*, right antenna; *e*, labrum epipharynx; *i*, anal fork. Immature larva (*D*): *f*, right antenna; *g*, right maxilla; *h*, labium. (Female): *J*, genitalia; *K*, bursa. (Male): *M*, oedaegus; *N*, genitalia (minus left harpe); *O*, side view of uncus minus hairs.

crawled underneath the calyx before they started to feed; few were observed to crawl directly between the drupelets on the outer surface of a berry. In each case the worms spun a small amount of silken webbing. Larvae feeding upon the fruit usually ate into one or two of the drupelets, causing them to become shriveled and discolored. In cases of severe infestation, as many as five young larvae were observed to be feeding beneath the calyx of one berry. One larva often injured several drupelets. The young worms tunneled down into the fruit, each eating a path between two drupelets or into a drupelet. Larvae apparently showed no choice between ripe and green fruits, readily feeding upon either.

The berry picking season at Granite was from July 5 to 25 in 1936. The height of the egg hatching period occurred after berry picking had begun, resulting in heavier infestations of later fruits. A large number of the newly hatched larvae established themselves upon dewberry foliage, usually selecting a folded leaflet or a point at which two leaflets touched. Because of the small size of the late summer larvae, damage to foliage seldom was observed except upon close examination. Larvae in fruits, fig. 1, D, usually continued to feed until the berries became dry. During the fall some larvae moved to the foliage from drying fruits. Some larvae remained in old dry berries on the bushes during late summer, and occasionally throughout the winter.

Hibernation.—*Cacoecia rosaceana* overwintered on dewberries in Utah as immature larvae 2 to 4 mm. in length. In 1936, larvae were found to be moving to hibernation during the middle and latter part of September. In hibernation they completely surrounded themselves with a tightly woven silken chamber. Such chambers were concealed beneath the bud scales, located in narrow cane crotches, beneath loose pieces of bark, in the acute angle of the leaf petiole crotch, or between two adjoining old leaf petioles. Larvae usually hibernated in the cloth cage sleeves when caged, the percentage surviving under such conditions usually being low. One larva was observed to survive the winter of 1935–36 within a silken tube in a dried dewberry. The small hibernating larvae were rather pale whitish yellow.

Spring larvae.—Most of the larvae had emerged from hibernation by mid-April of 1936, when dewberry plants were beginning to put out new foliage. The overwintered larvae were 2 to 4 mm. in length and had the same whitish yellow to yellowish green appearance as when they entered hibernation. Upon leaving hibernation the larvae began tying and folding the new leaflets together and feeding inside of the leaf masses. Larval growth was rapid during the spring; as the larvae grew they consumed larger quantities of foliage. As flowers, buds and blossoms began to appear they also were tied in with the leaflets, being fed upon and destroyed by the leaf-rolling larvae, fig. 1, C.

The voracious feeding habits and an apparent wandering instinct led many of the larger larvae to go in search of food several times before larval maturity was reached. A larva would crawl out of one leaf mass, usually moving outward toward the tip of the cane previously fed upon. Soon another bunch of leaflets and blossoms would be tied into a protecting bunch, feeding being resumed in the new location. It sometimes was possible to locate three to five places where a single worm had fed

during the latter part of May and early June. Infestations in many fields were low, but where severe infestations occurred, five to 15 maturing larvae often were found feeding upon one dewberry plant. With large worms spinning together and feeding upon two or more bunches of leaflets, foliage damage to the plants sometimes was severe.

The spring feeding period lasted from approximately the middle of April until late in June. The first prepupae were found in the field on June 11, 1936, and both larvae and pupae could be found from this time on throughout June. Spring larvae were collected upon black currants and roses besides dewberries.

The identity of the worms attacking dewberry fruits was first obtained by collecting larvae from fruits during the summer of 1935 and confining them in cages upon dewberry plants at Logan. The cages used were quart fruit jars with a cloth sleeve attached to the mouth of each; the larvae were allowed to feed upon dewberry foliage confined within the jars. When the larvae were ready to hibernate they crawled into folds of the cloth sleeve. The jars containing the hibernating larvae were wrapped in burlap and left in the field all winter. The following spring the surviving larvae were placed upon dewberry foliage in the laboratory and allowed to complete their development. Adults, fig. 1, A, obtained in this manner all proved to be *Cacoecia rosaceana* (Harr.), the oblique-banded leaf roller.[1]

Pupae.—During June some of the larvae underwent a distinct change in color and appearance. The body became shorter, stout and darker yellow, this being accompanied by a marked reduction in activity. This prepupal stage usually lasted for two to three days, then pupation occurred. The first pupa was observed on June 11, 1936; the last July 1. Each pupa remained within the mass of folded leaves last fed upon by its maturing larva until nearly ready for emergence; the anterior end of many empty pupal cases protruded from the leaf mass when adult emergence was completed. First emergence was noted on June 19, 1936. The pupal period under cage conditions ranged from nine to 16 days, the average being 12 days. The pupae were active when disturbed, and wiggled vigorously if removed from their place of attachment. The end of each abdomen is armed with small, hooked spines, fig. 1, B, used to anchor the pupa to the silk within the tied mass of leaves.

Adults.—The first moths, fig. 1, A, emerged in cages and were also observed in the field on June 22, 1936, although one empty pupal case was found three days earlier. Last emergence in cages occurred July 7. Reared individuals and collections of adults taken in dewberry patches indicated that males and females occurred in approximately equal numbers. Moths could be found throughout the day, partically concealed where they rested upon dewberry foliage. Moths were not observed to fly during the day unless disturbed; light trap collections indicated nocturnal activity. When disturbed during the day the moths usually would take a short flight, darting along jerkedly for from approximately 10 to 25 feet. Mating was not observed to occur during the daylight,

[1] The writers are indebted to August Busck, associate entomologist, Bureau of Entomology and Plant Quarantine, who identified the reared and field-collected material as *Cacoecia rosaceana* (Harris), the oblique-banded leaf roller.

although paired moths were under observation for several weeks. Females in cages laid fertile eggs within two days after emergence, so that apparently mating occurred within the first day or two. Caged moths invariably laid their eggs upon the celluloid of small cylindrical cages, on the glass sides of fruit jars, and on the sides of 25-pound paper bags used during egg laying studies. Moths in large gauze-covered cages 4 feet square, each of which covered an entire dewberry plant and its surrounding weeds, laid their eggs upon the upper surface of dewberry and ground cherry leaves. Individual females laid from 240 to approximately 900 eggs each, the average being 420 eggs. Exact counts were difficult to make, particularly in the larger egg masses. One moth began ovipositing on the night of June 28 and laid eggs each night until July 5, the total number being approximately 900 eggs. Most caged moths oviposited on but three or four nights. Under cage conditions adult males lived from three to 16 days, averaging 7.2 days; females survived three to 17 days, the average length of life being 8.1 days.

Generations.—Only one generation a year was indicated by the studies conducted during 1934 to 1936. No evidence of overwintering eggs, larval or adult maturity in the fall, or any partial second brood was evident during the seasons indicated.

Control.—Careful pruning of the dewberry bushes during early spring, several weeks before the first buds burst, and prompt burning of pruned canes and litter from around the bushes, materially lessened injury in fields at Granite where this practice was followed. Hand picking and destruction of caterpillars in infested leaf masses before May 15, reduced subsequent worm injury to berries and foliage. After this date many of the leaf masses examined did not contain worms.

Biological Control.—Several parasites were reared from the larvae and pupae of *Cacoecia rosaceana* (Harris). The dipterous parasite *Phorocera erecta* Coq. (Det. D. G. Hall) was reared from pupae collected at Granite and Pleasant Grove during June 1936. The hymenopterous parasites *Itoplectis atrocoxalis* (Cress.) and *Glypta simplicipes* Cress. were reared from larvae collected at Granite, July 5, 1936 (Det. R. A. Cushman). *Macrocentrus amicroploides* Vier. and *Microdontomerus fumipennis* Cwfd. and the hyperparasite *Catolaccus aeneoviridis* (Gir.) were reared from parasitized larvae collected at Granite and Pleasant Grove (Det. Dr. C. F. W. Muesebeck). A spider in one instance invaded a small celluloid cage and attacked a young larva; there was some evidence that this also occurred under field conditions.

Summary.—The tiny worms attacking dewberry fruits in northern Utah (Knowlton, 1935) have been identified as oblique-banded leaf roller larvae. Eggs were laid in masses upon the upper side of leaves during late June and the first half of July. The larvae from these eggs remained small, feeding upon dewberries and dewberry leaves until the cool temperatures of fall caused them to spin their hibernacula in protected places; within this silken retreat the winters were passed. Larvae emerged in spring in time to tie and web young developing dewberry leaflets. Growth was rapid during the spring, the larvae reaching a length of 18 to 28 mm. before maturity was reached. Pupation occurred from June 11 to July 1 during 1936, with adult emergence in cages occurring from

June 19 to July 7. Reared parasites included four species of Hymenoptera and one of Diptera. In at least one case, a spider was observed to attack a leaf roller larva.—4-1-37.

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Tests of Insecticides for Cotton Boll Weevil and Bollworm Control

Using the Latin Square Plat Arrangement and Analysis of Variance[1]

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Cotton boll weevil, *Anthonomus grandis* Boh., and the bollworm, *Heliothis obsoleta* Fab., are among the oldest and most serious pests of cotton in Texas. Control tests for these insects, using acre-size plats, have been conducted at this station for a number of years, but in analyzing the results from these large plats it has not always been possible to determine accurately whether the differences in yields were due to different insecticides or to soil variation. Since the Latin square plat arrangement has been sucessfully used in tests for the control of the cotton flea hopper (Gaines 1937) it was deemed advisable to use this plat arrangement also in tests for boll weevil and bollworm control. The work herein reported was conducted in the Brazos river bottoms during the season of 1936 with the following objectives in mind: first, to determine the applicability of small plat tests for boll weevil and bollworm control; second, to determine the comparative effectiveness of calcium arsenate, calcium arsenate plus 25 per cent lime, calcium arsenate plus 5 per cent Paris green, and a calcium arsenate–sulfur 50:50 mixture in controlling these pests.

Arrangement of Plats.—The Latin square method of plat arrangement used in these tests is a modification of the randomised plat lay-out. In this arrangement the number of replications is made equal to the number of treatments. The plats within the square are arranged in a row-column system, so that each treatment will occur once in each row and once in each column; otherwise the arrangement is random. The Latin square used in the tests contained 25 plats, each six rows wide and 103.7 feet long, or one-twentieth of an acre in size. A buffer of two rows, or 7 feet, was left untreated between every two adjoining plats. The arrangement of the plats is shown in table 1.

Poison applications.—The dust applications were made early in the mornings (4:30 to 6:30 a.m.) with a one-row fan-type hand gun, while

[1] Technical contribution 369, Texas Agricultural Experiment Station.

[2] In cooperation with the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine. Thanks are due Mr. M. J. Janes, of the Texas Experiment Station, for assistance in obtaining the field notes.

the cotton was wet with dew. Applications were made on the following dates: July 10, 15, 20, 26 and 31, and August 5, 11, 14, 18 and 22. The kind and average amount of dust that each plat (one-twentieth acre) received per application were as follows: *A*, Untreated or check, none; *B*, Calcium arsenate, 6.9 ounces; *C*, Calcium arsenate plus 25 per cent

Table 1.—The arrangement of blocks in the Latin square for the determination of boll weevil infestation, bollworm injury, and the yield in insecticide tests at College Station, Tex., 1936.

Latin Square					Total of Rows
D*	A	E	C	B	
10.1†	21.6	14.9	15.6	10.2	72.4
5.2‡	22.8	7.3	11.9	7.3	54.5
48.§	15.9	40.9	31.6	35.1	171.5
E	C	A	B	D	
11.9	16.1	24.	12.5	9.9	74.4
5.7	11.8	25.2	5.4	5.3	53.4
42.5	33.7	13.4	33.2	41.3	164.1
B	E	C	D	A	
12.5	9.4	12.6	12.4	22.8	69.7
6.1	6.1	9.9	6.	24.2	52.3
38.4	38.6	31.6	35.2	14.	157.8
A	B	D	E	C	
27.8	14.3	13.3	9.5	10.9	75.8
21.4	7.2	5.1	5.1	8.5	47.3
12.4	29.5	32.2	31.5	23.8	129.4
C	D	B	A	E	
7.5	9.7	10.4	16.4	9.1	53.1
6.3	4.	6.	20.9	6.3	43.5
15.2	19.7	20.6	11.5	24.6	91.6
		Total of Columns			
69.8	71.1	75.2	66.4	62.9	345.4
44.7	51.9	53.5	49.3	51.6	251.
156.5	137.4	138.7	143.	138.8	714.4

* The letters indicate the different treatments.
† The figures listed first in each block represent the average percentage of squares infested by the boll weevil, from eight records, from July 14 to August 24, inclusive.
‡ The figures listed second in each block represent the average percentage of forms injured by the bollworm, from five records, from July 30 to August 24, inclusive.
§ The figures listed third in each block represent the yield in pounds of seed cotton.

lime, 6.6 ounces; *D*, Calcium arsenate–sulfur[3] 50:50 mixture, 14 ounces; *E*, Calcium arsenate plus 5 per cent Paris green, 6.9 ounces.

All poison dusts contributed to an increase in the numbers of aphids. The number of aphids in each plat was recorded on a sample of 20 sections, cut from 20 leaves on 20 plants, each section 1½ inches in diameter and taken from the top leaf on the plants. These records, taken before and after an application of a 2 per cent nicotine dust on August 6, indicated that nicotine at this strength was ineffective in controlling the aphids. Later, in August, the infestation was greatly reduced by climatic conditions and natural enemies.

[3] Conditioned dusting sulfur.

Boll weevil infestation.—The record of boll weevil infestation in each plat was taken by counting at least 100 squares at two points selected at random and noting the percentage of punctured squares. These records were taken on July 14, 20, 25 and 30, and August 4, 10, 17, and 24. The different poisons were equally effective in reducing the infestation after each application.

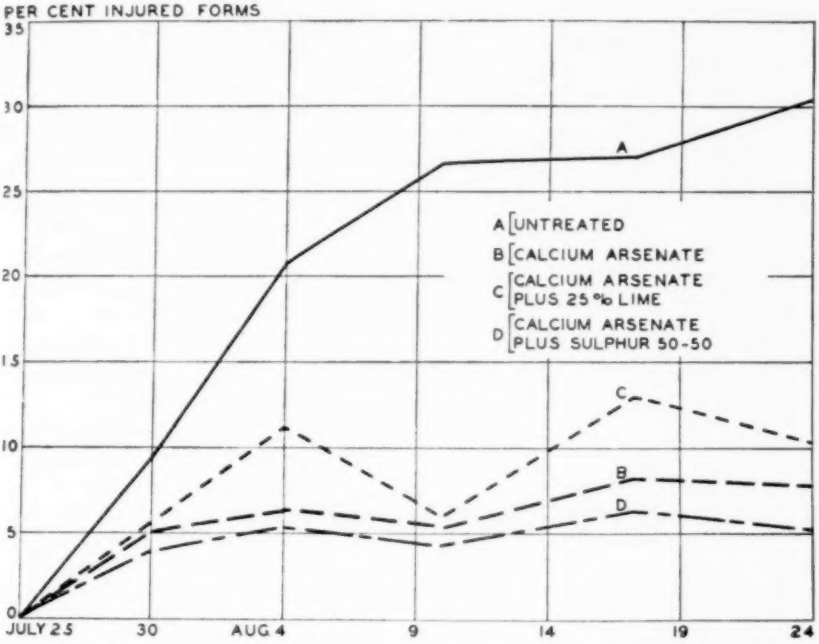

Fig. 1.—The average per cent of bollworm-injured forms on the groups of plats receiving the following treatments: A, untreated; B, calcium arsenate; C, calcium arsenate plus 25 per cent lime; D, calcium arsenate–sulfur 50:50.

Bollworm injury.—The records of bollworm injury were made by counting at least 100 squares and 100 bolls at two points selected at random in each plat. The percentage of injured forms (squares and bolls) was recorded for each plat on July 30 and August 4, 10, 17 and 24. The average percentage of injured forms from July 30 to August 24, inclusive, on each group of plats receiving the same treatment, is shown in fig. 1.

Yield.—The total number of plants was counted on each block. The average number of plants on each group of blocks receiving the same treatment was as follows: *A*, 1276; *B*, 1232; *C*, 1188; *D*, 1252; and *E*, 1231. These records indicate that the stand was as uniform as could be expected and that there was not enough variation to affect the yield. The yields, pounds of seed cotton, were obtained from each of the Latin square plats. The large difference in yields between the untreated or check plats and the dusted plats indicates that a fair profit was made

from the dusting operations, in spite of the large number of applications that were necessary.

Results.—Table 1 shows the average percentage of punctured squares for boll weevil infestation, the average percentage of injured forms for bollworm injury, and the average yield in pounds of seed cotton for each of the 25 plats. It can be seen that for each treatment there are five samples, a sample of the same treatment occurring once in each column and once in each row. These data were analyzed by the method of analysis of variance (Snedecor 1934). Table 2 shows the variance between different rows and columns attributed to the heterogeneity of the soil and uneven distribution of the insects. This variance is elimi-

Table 2.—Analysis of variance of boll weevil infestation, bollworm injury and yield of seed cotton from the 25 experimental blocks in insecticide tests at College Station, Tex., 1936.

Source of Variation	Degrees of Freedom	Boll Weevil Infestation		Bollworm Injury		Yield	
		Sum of Squares	Mean Square	Sum of Squares	Mean Square	Sum of Squares	Mean Square
Total	24	647.53	26.98	1135.38	47.31	2773.49	115.56
Between rows	4	68.04	17.01	17.29	4.32	860.67	215.17
Between columns	4	17.48	4.37	9.36	2.34	49.94	12.49
Between treatments	4	482.	120.5	1092.44	273.11	1666.8	416.7
Remainder	12	80.01	6.67	16.29	1.36	196.08	16.34

nated. Therefore, the remaining variance, denoted by 12 degrees of freedom, provides an unbiased estimate of the errors in the comparison of the treatments.

Boll Weevil.—The standard error of the difference in boll weevil infestation between any two treatments is

$$\sqrt{\frac{6.67}{5}} \times 2 = 1.63$$

In the table of t, for a probability of .05 the value of t, or the ratio of a difference and its error, is 2.179 for 12 degrees of freedom. Therefore, the required difference that would indicate significant results would be

$$2.179 \times 1.63 = 3.55$$

per cent punctured squares. The average number of punctured squares found on the check blocks was significantly greater than the average number found on any of the treated blocks. It will be noted that the differences between the average number of punctured squares found on the blocks that received treatments *B*, *C*, *D* and *E* were not significant. All treatments were equally effective in controlling the boll weevil. The lime, sulfur or Paris green that was added to the calcium arsenate on blocks *C*, *D* and *E* did not affect the toxicity.

Bollworm Injury.—Calculated as for the boll weevil, the difference between means (table 3) of the percentages of injured forms found on the several groups of blocks receiving different treatments must be 1.61 or greater to be significant. The injury on the check blocks was significantly

greater than that found on any of the treated blocks. Differences in injury found on the blocks that received treatments *B*, *D* and *E* were not significant, but the differences between the injured forms on these blocks and on the blocks that received treatment C were significant. Calcium arsenate, *B;* calcium arsenate–sulfur 50:50, *D;* and calcium arsenate plus 5 per cent Paris green, *E*, were equally effective in controlling bollworms, but when calcium arsenate was mixed with 25 per cent lime, *C*, the control was decreased. The percentage of injured forms was 3.8 higher on the group of blocks receiving treatment *C* than on the average of the groups of blocks receiving the other treatments.

Table 3.—Mean percentage of punctured squares for boll weevil infestation, mean percentage of injured forms for bollworm injury, mean yield of seed cotton for the five treatments, and difference between two means necessary for significance in insecticide tests at College Station, Tex., 1936.

Treatment	Per Cent Punctured Squares in Boll Weevil Infestation	Per Cent Injured Forms in Bollworm Injury	Yield of Seed Cotton, Pounds
B—calcium arsenate	12.	6.4	31.4
C—calcium arsenate plus 25 per cent lime	12.5	9.7	27.2
D—calcium arsenate–sulfer 50:50	11.1	5.1	35.3
E—calcium arsenate plus 5 per cent Paris green	11.	6.1	35.6
A—check	22.5	22.9	13.4
Significant Difference	3.55	1.61	5.57

Yield.—The difference between means of the number of pounds of seed cotton (table 3) receiving different treatments must be greater than 5.57 to be significant. The yield on the check blocks was significantly less than that on any of the treated blocks. These differences were large, indicating the severe injury and loss that occurred from both weevils and worms. The differences in yield on blocks that received treatments *B*, *D* and *E* were not significant, but the differences in yield on blocks that received treatments *D* and *E* were significantly greater than on the blocks that received treatment *C*. The 4.2 to 8.4 pounds increase in yield of seed cotton on the group of blocks that received treatments *B*, *D* and *E* over that of *C* (calcium arsenate plus 25 per cent lime) again indicates that the last-named mixture was not so effective as the other materials in controlling bollworms.

Summary.—The Latin square block arrangement, using one-twentieth-acre blocks, was applicable for use in tests for boll weevil and bollworm control. By this method of block arrangement with the replications, the variation due to heterogeneous soil and uneven distribution of insects was eliminated, thus increasing the value of the experiment. The analysis of variance eliminated much guesswork in the interpretation of the data.

In these tests, calcium arsenate, calcium arsenate–sulfur 50:50, calcium arsenate plus 5 per cent Paris green, and calcium arsenate plus 25 per cent lime were equally effective in controlling the boll weevil. The addition of sulfur, Paris green or lime did not affect the toxicity of the

calcium arsenate to the weevil but when the dosage of calcium arsenate was reduced 25 per cent by the addition of lime the toxicity to the bollworm was reduced. Sulfur, Paris green or lime did not prevent the increases of aphids that occurred on all the blocks.

The various insecticides were equally effective in controlling the boll weevil, but an average difference of 3.8 per cent increase in bollworm injury resulted from treatment C. This difference with the average difference in yield of 6.3 pounds of seed cotton that was obtained indicates that an average of 1 per cent injury during the time in which two broods of worms occurred reduced the yield on the plats about 1.7 pounds of seed cotton or 34 pounds per acre.—2-1-37.

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Control of Tobacco Flea Beetle in Plant Beds

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Control of the tobacco flea beetle, *Epitrix parvula*, in tobacco plant beds and fields is difficult. Several insecticides have been recommended in a number of recent reports. E. G. Beinhart (1932) recommends for use on plant beds a spray made of 50 gallons of Bordeaux mixture, 2 pounds of lead arsenate and 1 pint of 40 per cent nicotine sulfate solution. F. S. Chamberlin (1933) advises the use of a mixture of barium fluosilicate 8 parts, infusorial earth 2 parts, and finely ground tobacco dust 2 parts, or the infusorial earth may be omitted. This mixture was to be used on shade-grown tobacco in Georgia and Florida. W. H. White (1935) reports that barium fluosilicate dust used at the rate of one-half pound to 100 square yards of tobacco plant bed, and derris mixed with tobacco dust and containing 2 per cent rotenone, when used at the rate of 1 pound to 100 square yards of plant bed, are equally effective. Irene D. Dobroscky (1935) states that a natural cryolite and talc mixture of a 40:60 per cent strength may rightly be said to be specific for the tobacco flea beetle. Stanley & Marcovitch (1935) recommend the use of a barium fluosilicate compound or calcium arsenate.

Several insecticides were tried on the experiment station farm for controlling the flea beetle in plant beds in 1934, 1935 and 1936. Portions of beds were also enclosed by board frames covered with a good grade of tobacco cotton to determine the amount of protection given by this device. Infestations by the beetle were light during these three years. The results obtained from the use of the different measures were com-

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

pared in order to determine the most effective measure for protecting the plants. The findings are summarized in table 1.

General procedure.—The insecticides were applied in sections 5 feet wide across the plant bed with arrangement for five replications of each treatment. The sprays were applied with a compressed-air sprayer and the dusts with a plunger type of duster. The portions of the bed not being

Table 1.—Summary of results of control measures. The insecticides were applied May 16 and 22, 1934, May 14 and 25, 1935, and May 7 and 15, 1936.

Treatment	Year	No. Plants Examined	Per Cent Injured
Bordeaux mixture 3:3:50, lead arsenate 2 pounds, nicotine sulfate (40 per cent soluble) 1 pint	1934	849	22.38
	1935	789	15.58
Same as above without nicotine sulfate	1934	924	29.11
	1935	703	20.2
Paris green 1 part, lead arsenate 4 parts, hydrated lime 1 part; Dust	1934	904	24.44
Barium fluosilicate with 20 per cent inert material; Dust	1934	888	12.5
	1935	716	13.26
	1936	1030	15.43
Cuprous cyanide 2½ pounds, 100 gallons of water	1935	664	25.15
Control, no treatment, loose cover	1934	789	43.08
	1935	782	31.58
	1936	997	31.89
Boxed bed, no treatment, tight cover	1934	875	4.91
	1935	784	1.53
	1936	861	2.2
Synthetic cryolite; Dust	1936	1159	19.15
Derris dust, 1 per cent rotenone	1936	1107	27.55
Derris dust, 2 per cent rotenone	1936	1078	27.08

treated when insecticides were being applied were covered with canvas tarpaulins to give protection from drifting material. Injured plants were counted in five samples for each replication. The samples were taken at random and included all the plants enclosed in a wire frame 1 foot square.

The sprays were applied at the rate of 1 gallon to 30 square yards and the dusts at the rate of one-half pound to 100 square yards, except a 1-pound rate for the derris dusts. The barium fluosilicate dust was a commercial product containing 80 per cent barium fluosilicate and 20 per cent inert material. The synthetic cryolite dust contained 40 per cent synthetic cryolite and 60 per cent infusorial earth. The derris dusts were made of ground derris root and infusorial earth and contained 1 and 2 per cent rotenone.

The beds in which the insecticides were tested, and the controls, were covered in the usual way; that is, cotton cloth was stretched over wire loops in the bed and pinned to the ground with wires along the edges. This method gives little protection against insects. Portions of beds were boxed and covered with a good grade of tobacco cloth to act as a barrier. The board frame was closely fitted and soil was banked on the outside and tamped. The cloth was drawn down the outside edges of the boards and fastened by small nails.

Results.—The results were analyzed for proportional differences to determine which measure, if any, gave significantly better control. Bordeaux mixture containing lead arsenate is frequently recommended for controlling flea beetles. The addition of nicotine sulfate is said to increase the efficiency of this combination (Beinhart 1932). The Bordeaux mixture–lead arsenate combination with and without nicotine sulfate was used two seasons. In 1934, when nicotine sulfate was added, the proportion of plants injured was 22.38 per cent, and without the nicotine sulfate the proportion was 29.11 per cent, a difference of 6.73 per cent. The standard error of this difference is 2.068 per cent. The difference between the proportions is 3.25 times the standard error. In 1935, the difference between proportions was 4.62 per cent and the standard error of this difference 1.99. The difference is 2.32 times its standard error. The nicotine sulfate increased the efficiency of the Bordeaux mixture–lead arsenate combination and, at least in the 1934 tests, the increase was significant, since a difference of three times the standard error is considered significant. The Paris green–lead arsenate–hydrated lime dust and the Bordeaux mixture–lead arsenate–nicotine sulfate combination in 1934 show a proportional difference of 2.06 per cent. The standard error of this difference is 2.05 per cent. The difference and its standard error are practically equal, which indicates that the difference in favor of the Bordeaux mixture combination was not significant. The barium fluosilicate dust in 1934 and the Bordeaux mixture–lead arsenate–nicotine sulfate combination show a difference of 9.88 per cent. The standard error of this difference is 1.81 per cent and the difference is 5.45 times its standard error. These same insecticides in 1935 show a difference of 2.32 per cent with a standard error of 1.97 per cent. The difference is 1.17 times the standard error, showing that it is not significant. The barium fluosilicate dust and cuprous cyanide have a difference of 11.89 per cent. The standard error of this difference is 2.13 per cent and the difference is 5.58 times its standard error. The barium fluosilicate dust and derris dust containing 2 per cent of rotenone, in 1936, show a difference of 11.63 per cent of plants injured. The standard error of this difference is 1.78 per cent and the difference is 6.54 times its standard error. The statement that barium fluosilicate and derris dust (White 1935) are equally effective in protecting tobacco plants in beds from flea-beetle injury was not verified in this instance. The barium fluosilicate and synthetic cryolite dusts, in 1936, show a difference of 3.72 per cent. The standard error of this difference is 1.61 per cent. The difference is 2.3 times its standard error, a considerable difference in favor of the barium fluosilicate dust, although not enough to be significant.

The proportion of injured plants in portions of beds protected by

board frames with tight coverings of tobacco cloth were much less than where insecticides were used. Analysis of results obtained from the use of this protective measure and the barium fluosilicate mixture shows a significant difference for three seasons. In 1934, the difference between proportions was 5.71 times its standard error; in 1935, 8.75 times; and in 1936, 10.51 times.

Conclusions.—A board frame with a tight covering of tobacco cloth gave a much greater degree of protection than any of the insecticides used in these tests. The barium fluosilicate mixture, however, appeared to give significantly better control than any of the other insecticides tried.—3-10-37.

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Relation of Time of Day, Temperature and Evaporation to Attractiveness of Fermenting Sugar Solution to Mexican Fruitfly

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The studies herein reported were designed to show the relation of temperature and evaporation to the attractiveness of fermenting bait to the Mexican fruitfly, *Anastrepha ludens* Loew. The fact that time of day is quite an important factor was not suspected. In the laboratory similar problems are investigated by maintaining constant all variables except the one whose effect is to be measured. Obviously this cannot be done in the field. Other means must be adopted. First a series of paired observations must be made and then the relations may be determined by correlation methods. As to the latter, the writer employed the customary method of multiple linear correlation and Ezekiel's[1] method (1930) of multiple curvilinear correlation. In a problem involving multiple variables, these methods enable one to determine the relation of an independent variable to the dependent, simultaneously eliminating that

[1] The writer wishes to express his gratitude to Dr. Mordecai Ezekiel for having confirmed the applicability of his methods to this problem and for having reviewed a preliminary draft of the computations.

part of the variation in the dependent variable associated with other measured independent variables. Final results, therefore, are what one would expect under controlled laboratory conditions.

Field data.—The experimental data were taken at Cuernavaca, Morelos, Mexico, in mango trees. Except for slight winds late in the afternoon on all three days, the weather was calm and clear. Owing to the presence of an abundance of mangoes in a stage of growth favorable for oviposition, the fly population was concentrated and large. It was

Table 1.—Field records relative to the effect of time of day, temperature and evaporation on the attractiveness of fermenting sugar solution to the Mexican fruitfly, *Anastrepha ludens* Loew.

Date	Time of Day	No. Male Flies Captured	No. Female Flies Captured	Av. Temp. °C	Total Evaporation, Cc.	Observation No.
March 28, 1933	7 to 8:30 a.m.	12	2	19.6	4.1	1
	8:30 to 10 a.m.	35	14	22.3	6.	2
	10 to 11:30 a.m.	40	25	24.3	6.5	3
	11:30 a.m. to 1 p.m.	51	39	26.6	6.6	4
	1 to 2:30 p.m.	32	27	28.8	7.1	5
	2:30 to 4 p.m.	42	30	29.6	6.8	6
	4 to 5:30 p.m.	33	25	28.5	4.8	7
	5:30 to 7 p.m.	5	18	27.	3.5	8
March 29, 1933	7 to 8:30 a.m.	23	6	19.8	4.2	9
	8:30 to 10 a.m.	37	9	22.5	6.1	10
	10 to 11:30 a.m.	42	29	25.	6.3	11
	11:30 a.m. to 1 p.m.	37	24	26.8	6.9	12
	1 to 2:30 p.m.	29	24	28.	7.8	13
	2:30 to 4 p.m.	49	28	29.	6.8	14
	4 to 5:30 p.m.	25	26	28.8	4.6	15
	5:30 to 7 p.m.	3	14	27.5	3.5	16
March 30, 1933	7 to 8:30 a.m.	18	1	19.4	1.7	17
	8:30 to 10 a.m.	15	7	22.5	3.5	18
	10 to 11:30 a.m.	32	9	25.	5.2	19
	11:30 a.m. to 1 p.m.	30	19	27.	6.1	20
	1 to 2:30 p.m.	29	17	28.5	7.6	21
	2:30 to 4 p.m.	22	29	29.5	7.7	22
	4 to 5:30 p.m.	25	20	30.2	8.	23
	5:30 to 7 p.m.	18	34	29.1	6.5	24

evident that most of the population was old, a carry-over from the last season.

A summary of the records is given in table 1. An observation was made every hour and a half from 7 a.m. to 7 p.m. on three consecutive days. Each observation consisted in recording the following variables: (1) number of flies captured in 10 glass traps (sexes recorded), (2) time of day, (3) average temperature, and (4) evaporation rate.

Analysis of data.—In fig. 1 it is apparent that the sexes responded differently. Therefore, an analysis had to be made for each sex.

In both problems, in order to reduce the error due to fluctuations in fly population from day to day, the dependent variable was changed from the "number of flies captured" to "percentage of daily total catch." An example will make this change clear. On March 28, from 7 to 8:30 a.m., 12 male flies were captured. This was 4.8 per cent of the males captured that day.

Results.—Designating the percentage of the total daily catch as attractiveness, the dependent variable, by X_1, the time of day by X_2, the

average temperature by X_3, and the rate of evaporation by X_4, the linear relations are expressed in the following regression equations:

$$\text{Males: } X_1 = -35.1710 - 3.2327X_2 + 2.1954X_3 + .3175X_4.$$

$$\text{Females: } X_1 = -19.2790 + .4132X_2 + .8424X_3 + 1.4593X_4.$$

Literally these equations mean, using the equation for males as an illustration, that a fair estimate of the percentage of daily capture

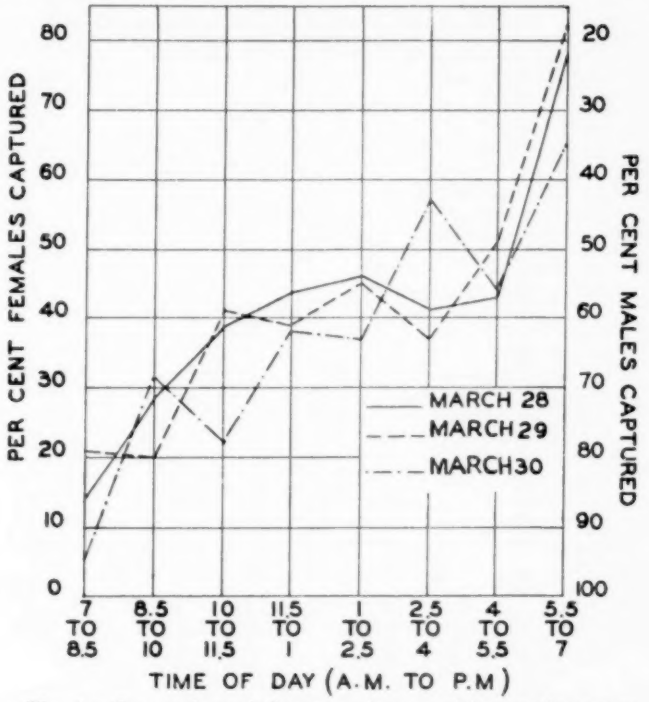

Fig. 1.—Comparison of the attractiveness of fermenting sugar solution to male and female Mexican fruitflies.

during any of the 24 1½-hour periods may be arrived at by allowing −3.23 per cent for each unit of time of day, 2.2 per cent for each degree of temperature, and .32 per cent for each cubic centimeter of evaporation and subtracting from the total of these the constant −35.17. In general terms, the attractiveness of the bait to males due to time of day decreased as the day grew older, while that due to temperature or that due to evaporation increased with a rise in temperature or an increase in evaporation. With favorable conditions of temperature and evaporation more males would be captured early in the morning than during any other time of day. In most sections, however, temperature and evaporation are very unfavorable at this time of day, consequently few flies would be captured.

The following statistics measure, in the order recorded, (1) the accu-

racy of estimate, (2) the degree of correlation, and (3) the per cent of variance accounted for.

	Males	Females
(1) Standard error of estimate	3.127 per cent	3.728 per cent
(2) Coefficient of multiple correlation	.783	.816
(3) Coefficient of total determination	61.3 per cent	66.6 per cent

From these statistics it is evident that after the part of the variance ascribable to linear relations has been removed there remains considerable variance not accounted for. This suggests (1) that there were other important variables operating, (2) that the number of observations was too small, (3) that the relations are not linear, or (4) that a combination of two or more of these conditions obtained.

Table 2.—Relative importance of time of day, temperature and evaporation on "percentage of daily total catch" of male and female Mexican fruitflies, as indicated by coefficients of part correlation.

Independent Factor	Factors Held Constant	Coefficient of Part Correlation		Coefficient of Part Determination	
		Males	Females	Per Cent Males	Per Cent Females
Time	temperature, evaporation	.924	.251	85.4	6.3
Temperature	time, evaporation	.922	.641	85.1	41.1
Evaporation	time, temperature	.166	.545	2.8	29.7

There were, without a doubt, important variables which were not considered; for example, light intensity, wind velocity, and a third, which is not climatic, the diurnal mating response. Regarding the last, previous insectary experiments showed that practically all mating took place late in the afternoon, commencing not earlier than 5:30 p.m. During this period of day all normal sexually mature males maintain a state of excitation and do not care to feed. Females, however, are calm, mating at intervals of days. The effect of this response was to upset the data somewhat.

The number of observations do appear small. It must be recalled, however, that 10 traps were employed. When calculated on the basis of individual traps, 240 samples were taken instead of 24, as recorded in the data. A better plan would be to increase the number of traps to 50 or more.

There was a difference in the response of the sexes. To study this difference the separate effect of the independent variables on males and on females was measured. These measurements are given in table 2.

Referring to the part correlation coefficients in table 2, it will be seen that temperature was the most influential factor on both sexes. Time of day was highly correlated with the response of males, but ranked third in its effect on females. The effect of evaporation was opposite to that of time; it was second in importance on the response of females, but was least important on the males. The coefficients of part determination which are given in the last two columns of the table tell the same story.

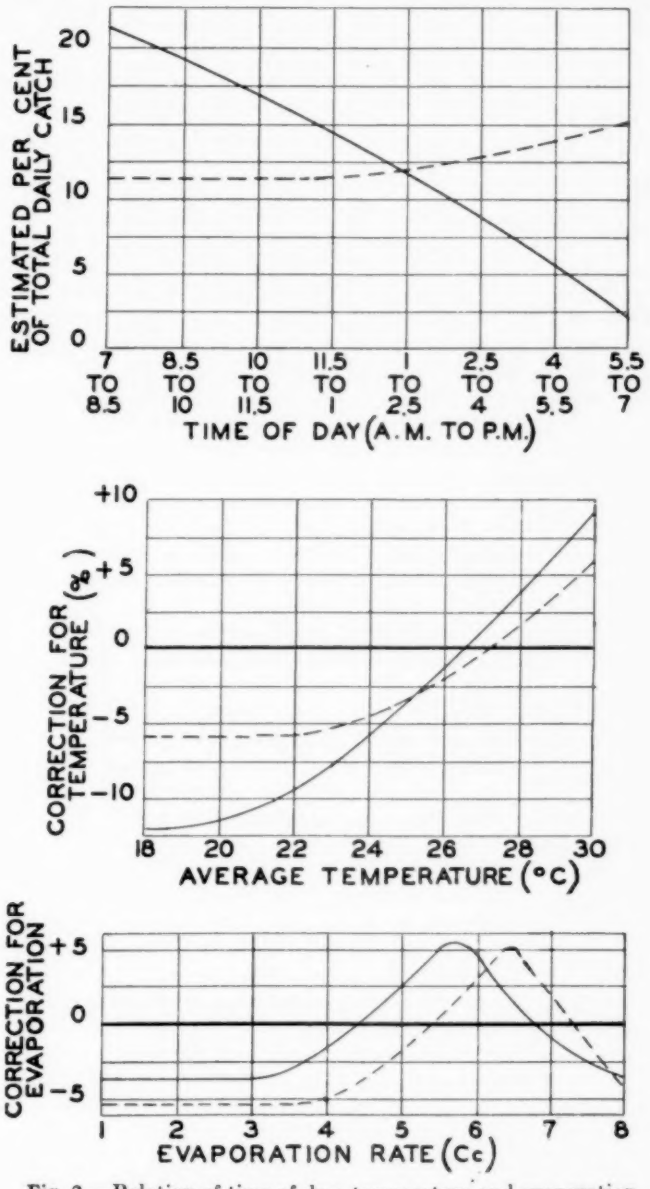

Fig. 2.—Relation of time of day, temperature and evaporation to the attractiveness of fermenting sugar solution to male and female Mexican fruitflies as indicated by Ezekiel's method of multiple curvilinear correlations. Males, solid line; females, broken line.

They measure the proportion of the variance remaining in the dependent factor which can be explained by a given independent factor after the net effects of the other variables have been removed.

To determine the adequacy of the linear estimate, curvilinear correlation methods were applied with the following results:

	Males	Females
(1) Standard error of estimate	2.841 per cent	3.647 per cent
(2) Index of multiple correlation	.817	.825
(3) Index of total determination	68.1 per cent	68.1 per cent

When these statistics are compared with those for the linear relations, it is observable that there is hardly any statistical evidence in favor of curves for females. Curves, however, fit the male data somewhat better, accounting for 68.1 per cent of the variance, an increase of 6.8 per cent over the straight line.

The curvilinear relations arrived at are presented in fig. 2. The time-of-day effect is given in actual values of the dependent variable, while the effect of temperature and the effect of evaporation are given in departures from values which would otherwise prevail. Such curves are called prediction curves, because from them one is able to read directly the value of the dependent variable for any combination of independent variables covered by the data. This feature of the curves will be appreciated if estimated values of X_1 for each of the 24 observations are read off and compared with the linear estimate.

Summary.—A study is given of the relation of temperature, time of day and evaporation rate on the attractiveness of fermenting sugar solution to the Mexican fruitfly in the field at Cuernavaca, Morelos, Mexico.

To obtain field data the day was divided into eight 1½-hour periods beginning at 7 a.m. and ending at 7 p.m. During each of these periods the following variables were recorded: (1) number of flies attracted to 10 glass fly traps baited with fermenting sugar solution, (2) time of day, (3) average temperature, and (4) evaporation rate. A total of 24 observations were made on three consecutive days.

There was a difference in the response of the sexes. Therefore, in the analysis, they had to be dealt with separately.

To study the relations, the method of multiple linear correlation was employed. It was found that time of day, temperature and evaporation account for 61.3 per cent of the variance in the number of males attracted and for 66.6 per cent in the case of females.

To study the difference in the response of the sexes, the separate effect, of each of the factors on males and on females was calculated. Part correlation coefficients were employed. For males the order of importance was (1) temperature, (2) time of day, (3) evaporation; and for females it was (1) temperature, (2) evaporation, (3) time of day.

To test the adequacy of the linear estimates, Ezekiel's method of multiple curvilinear correlation was applied. It was shown that there was hardly any statistical evidence in favor of curves for females. Curves, however, fit the male data somewhat better than do straight lines, accounting for 68.1 per cent of the variance.—2-10-37.

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Introduction of *Thripoctenus brui* Vuillet, Parasite of *Thrips tabaci* Lind., from Japan to Hawaii

K. SAKIMURA, *Pineapple Experiment Station,*[1] *Honolulu, Hawaii*

Introduction into Hawaii of *Thripoctenus brui* Vuillet from Tokyo was undertaken from 1932 to 1934 for the purpose of combating *Thrips tabaci* Lind., which in Hawaii is the vector of pineapple yellow spot virus. The problem of collection and shipment of the parasite from Tokyo was assigned to the writer and the reception and care of the parasites in Honolulu to Dr. Carl T. Schmidt, the whole project being under the direction and supervision of Dr. Walter Carter.[2]

Studies of the seasonal life histories of *T. tabaci* and the bionomics of the parasite in Japan have been prepared concurrently with this article and are now in press (Sakimura 1937a, 1937b).

Status of the host and parasite in Japan.—*T. tabaci* is present throughout the year and is extremely injurious to onions grown over a large area. Its period of greatest activity is from June to August. The parasite *T. brui* appears in June coincident with the beginning of the period of abundance of the host and its activity continues until early October. During the latter half of the summer season the percentage of parasitism becomes high and a material factor in the control of the host.

Method of collecting field material.—Laboratory breeding of the parasite is difficult and cannot be compared in efficiency with field collecting. Standing onion plants in the field were beaten onto a black cardboard and the host larvae which dropped onto the cardboard were then collected by means of sucking tubes. Detailed description of this method is included in other papers (Sakimura 1937a, 1937b). By this method large quantities of host larvae could be collected and the parasites from these were easily reared to pupal stage under confinement in glass tubes covered with silk cloth at both ends. Daily collection trips were made during the season and material accumulated for each boat sailing for Hawaii. This, on the average, meant three or four shipments a month and the shipping season was from June or July until October.

Method of shipping.—Russell (1912) reported that the pupal form of *Thripoctenus russelli* Crawford on *Hercothrips fasciatus* Perg. could be successfully shipped in cold storage for distances as great as those from California to Washington, D. C. The same species was shipped from California to Hawaii during 1930 and 1931, using the cool temperatures

[1] Published with the approval of the Director as technical paper 98 of the Pineapple Experiment Station, University of Hawaii.

[2] Other acknowledgments are due to K. Ando, S. Kinoshita, T. Ishii, A. Kamito, S. Kariya, M. Kurosawa, K. Kurosawa, K. Kuraishi, S. Yamasaki, M. Yamanouchi, S. Fuji and F. Umoto, of various Japanese institutions

of the ship's vegetable rooms, and a fair percentage of the parasites emerged upon arrival in Hawaii. The pupal stage of *T. brui* is about two weeks during the summer months, and the voyage from Yokohama to Honolulu a matter of seven or eight day's duration. It was presumed that low temperature shipments would be satisfactory. This method was used until the end of the first season of 1932. Parasite pupae were enclosed in folded papers and inserted into glass vials which were plugged with cotton or silk cloth, or at times packed in with lumber shavings or rolled in cottom. These vials were packed in tin cans, together with moistened absorbent cotton and the cans sealed tightly. Some 28,415

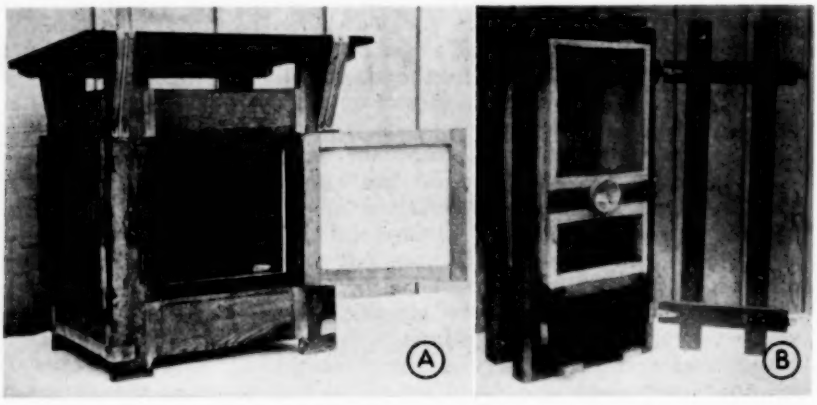

Fig. 1.—Shipping cages for *Thripoctenus brui* Vuillet. *A*, Wardian shipping cage used for transportation from Japan to Hawaii. *B*, Inter-island shipping cage used for transportation from Honolulu to other Hawaiian islands.

pupae in 12 shipments were sent from Yokohama to Honolulu packed in this manner and carried in the vegetable rooms or in cool cabins of the steamers, but with very rare exceptions, none emerged. The few adults that did emerge were very weak and failed to reproduce under laboratory conditions. Towards the end of 1932 shipments of parasitized host larvae were attempted using sprouted onion bulbs packed in small ventilated tin cans. The results from this were also negative. With the beginning of the 1933 season the shipping of parasitized host larvae on green onion plants packed in large wardian cages carried in cool quarters of steamers was initiated. The wardian shipping cage used is illustrated in fig. 1, *A*, and was designed by Dr. Schmidt. The inner dimensions are 12 by 16 by 9 inches high—in some cases 16 inches high. The cage consists of a sturdy wood frame covered with brass 100-mesh screen on the outside and lined with tightly woven silk cloth on the inside at the four sides and top. An inclined wood roof is provided. Two doors at opposite sides open on hinges, the other two sides and top can be detached by means of wood screws. In order to provide tight joints thick felt was fastened to the frames where the sides and top meet. The bottom, made of wood, has a drainage hole covered with brass screen and tightly woven cloth. All the joints of the cage were thoroughly sealed with putty and

zinc oxide adhesive plaster before shipping. A loose frame to hold six No. $2\frac{1}{2}$ cans was placed at the bottom of each box. Cans containing planted green onions were placed in the cage. After being set the remaining floor space was filled with 2 to 3 inches of soil. All soil used was deep subsoil mixed with well-aerated peat, the whole being thoroughly fumigated with strong doses of carbon bisulfide. The peat mixed in the soil provided favorable pupation quarters for the larvae which pupated en route as well as helping to maintain proper moisture conditions.

The field-collected host larvae, carefully sorted to exclude foreign insects, were transferred to the onions in the cages on which they completed their larval stages. Observations showed that host prepupae within the cages could be detected in the plant debris, leaf sheaths and in the soil but the favored location for pupation was in the soil. From 10,000 to 20,000 host larvae were transferred to each cage. Since parasitized host

Table 1.—Number of *Thripoctenus brui* Vuillet liberated in Hawaii during 1933 and 1934.

YEAR	OAHU	MAUI	MOLOKAI	LANAI	TOTAL
1933	16,284	7,763	95	905	25,047
1934	4,750	11,820			16,570
Total	21,034	19,583	95	905	41,617

larvae could not be distinguished in external appearance from unparasitized larvae the parasitized proportion of the number mentioned could not be determined but on the basis of field readings it was estimated that the percentage of parasitism ranged from 67.4 to 6.1 per cent. Mortality en route varied considerably but a total of 27,531 adults emerged from the 1933 shipments and 16,575 emerged from the 1934 shipments.

Reception and liberation.—Although some adults were found alive and active on arrival most of the emergence took place some days after being received in Honolulu. Careful checking of individual specimens was conducted until it was evident that no hyperparasitism existed in the material. Although Dr. Schmidt succeeded in breeding two generations of *T. brui* from Japan on Hawaiian *T. tabaci* in the laboratory the number of specimens of *T. brui* emerging from shipments was so great as to warrant immediate release. An important factor in the establishment of any introduced parasite is the concentration of the insect host and the frequency of its host plant. In and around pineapple fields *T. tabaci* populations were found on weed hosts but in low concentration on any particular host. For that reason it was decided to liberate *T. brui* in onion plantings where the concentration of the host was high. In some cases onion patches were purposely planted in the vicinity of pineapple plantings in order that this necessary concentration of insect host could be brought about.

Records on liberation are presented in table 1. On the island of Oahu the emerged adults were released directly from glass jars in neglected and fallow lands where *T. tabaci* populations were comparatively high or in areas where the yellow spot disease was prevalent. Some of them were released in onion patches in suburban truck gardens of Honolulu or in onion patches planted around pineapple plantation camps. On the

outside islands a special shipping cage designed by Dr. Carter was employed. This is illustrated in fig. 1, *B*. The inner portion, 14 by 14 by 40 inches, is constructed of galvanized iron frame, covered with broadcloth at the two sides and top and automobile celluloid on the other two sides, with two large alcoves for introducing parasites after the cage was closed. The bottom, also made of metal, 8 inches deep, is fastened at the top by means of detachable bolts and screws. Onion plants were planted in the bottom part but in order that both soil and plants could be removed without disturbing the soil and plant roots too much, pieces of gunny sacking were laid at the bottom of the container so that the whole mass could be lifted out on arrival on the other islands. The soil was thoroughly fumigated in order to avoid inter-island shipment of soil insects. A strong wooden crate was used to protect the cage while en route. Adult parasites were transferred to these cages where a considerable population of *T. tabaci* had been previously established. Oviposition by the parasite was generally observed. On arrival at destination the onion plants with their colonies of host and parasite were removed bodily with the accompanying soil from the cage and planted in an area where additional hosts were present. All liberations on the island of Maui were in onion plantings at the windward edge of pineapple plantations.

Summary.—*Thripoctenus brui* Vuillet was successfully introduced from Japan to Hawaii during the seasons of 1933 and 1934, when approximately 44,000 adults arrived in good condition. Shipment of parasite pupal forms was not successful, it being necessary to ship parasitized host larvae. Specially constructed wardian cages for carrying the parasitized host larvae on favored host plants were found quite satisfactory and for inter-island shipping a suitable cage was devised which permitted the sending of a host parasite colony established on a favorable host plant for the insect host. Twenty-one thousand thirty-four adults were liberated on Oahu, 19,583 on Maui, 95 on Molokai and 905 on Lanai. —5–19–37.

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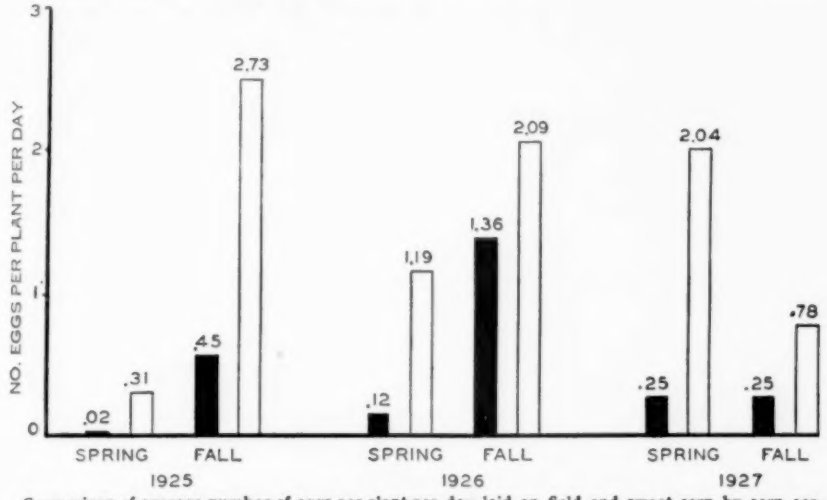
Scientific Notes

Preference of Corn Earworm Moths for Sweet Corn for Oviposition.—Field observations on the rate of infestation of sweet corn as compared with that of field corn by larvae of the corn earworm, *Heliothis obsoleta* F, has seemed to suggest that sweet corn is more attractive to moths for oviposition and, consequently, receives greater numbers of eggs than does field corn. While this subject is of considerable importance in studies of control of the insect, no definite information on this question appears to have been available heretofore.

Information was obtained in 1925, 1926 and 1927 at Charlottesville, Va., which established the fact that sweet corn received a much greater number of eggs than field corn. During the stated years the seasonal occurrence and abundance of eggs of the corn earworm moth were studied by daily observations of the number of eggs laid on representa-

tive corn plants of successive plantings of field corn and sweet corn. For this entire period, covering three entire growing seasons, 5032 eggs were recorded on sweet corn during 3359 daily observations, and 4623 eggs on field corn during 10,682 daily observations. Thus the occurrence of eggs on sweet corn was at the average rate of 1.5 per plant per day for the three-year period, while .4 egg per plant per day was recorded on field corn. During the three-year period, therefore, 3.5 times as many eggs of the corn earworm moth were recorded on sweet corn as on field corn.



Comparison of average number of eggs per plant per day laid on field and sweet corn by corn earworm moths; solid columns show eggs laid on field corn and outlined columns show eggs laid on sweet corn.

While the abundance of eggs of the corn earworm moth was variable each year, and during each season of each year, the preference for sweet corn was always observed. This is shown in the figure above. Each year was divided into two parts, *viz.*, a spring season in June and July and a fall season in August and September, the stated seasons always being separated by a period of a few days, or a week or more, when eggs were very scarce or were not recorded at all. During the spring seasons of 1925, 1926 and 1927, eggs were, respectively, 15, 10 and eight times more plentiful on sweet corn than on field corn, while during the fall seasons of these years they were 6, 1.5 and 3 times more plentiful on sweet corn.

G. W. BARBER, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*—8-11-37.

Number of Short-winged Chinch Bugs Produced under Laboratory Conditions.—While studying the effect of different varieties of sorghum and corn on the biology of the chinch bug, *Blissus leucopterus* (Say), at Lawton, Okla., interesting observations have been made on the percentage of short-winged forms that were reared. Nymphs hatched from eggs laid by long-winged females feeding on barley in the laboratory were used in these experiments. The young nymphs were confined in individual cages with seedling plants of different varieties of sorghum and corn. In 1935 a total of 52 bugs were reared and of this number 23, or 44.2 per cent, were short winged. In this experiment the bugs were reared to maturity on Atlas sorgo and Dwarf Yellow milo.

In 1936 a total of 354 chinch bugs were reared in the laboratory of which 143 or 40.4 per cent were short winged. Nine varieties of sorghum and three of corn were used as food plants. Five of the sorghum varieties were resistant but the remaining four were susceptible. one of the corn varieties was resistant, one was susceptible, and the remaining varieties were intermediate between the two in resistance. There was no indication of any relation between the numbers of short-winged forms produced and the resistance or susceptibility

of the host plants. The percentages of short-winged bugs observed in the first, second and third generations were 55.3, 37.9 and 19.8, respectively. Of the 158 female chinch bugs reared 56, or 35.4 per cent, were short winged, while 87, or 44.39 per cent, of the 196 males reared were short winged.

Ordinarily, under field conditions in the southwestern part of Oklahoma, considerably less than 1 per cent of the chinch bugs are short winged. Of 2000 third-generation chinch bugs collected in the field in 1936, only six, or .3 per cent, were short winged.

R. G. DAHMS, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine* and *Oklahoma Agricultural Experiment Station, Department of Entomology, cooperating.*
7-12-37.

Composition of Paris Greens Manufactured During 1936.—To obtain information on the composition of the various brands of Paris green manufactured in 1936, the various insecticide manufacturers were asked for samples. In response to this request nine samples were submitted. The nine samples were analyzed in accordance with the method of the Association of Official Agricultural Chemists (1935), and the results are given in table 1 The physical characteristics of these samples, such as density, particle size, and bulking value, were reported by Goodhue & Gooden (1937).

Table 1.—Analyses of commercial samples of Paris green (percentages).

Sample	Arsenic Trioxide (As_2O_3)	Arsenic Pentoxide (As_2O_5)	Total Copper as CuO	Sodium Acetate-Soluble As_2O_3	Water-Soluble As_2O_3	Moisture
A	57.29	.2	30.56	.6	.60	.76
B	57.03	.0	30.05	.67	.94	.68
C	56.95	.2	30.56	.72	.94	.53
D	57.04	.09	30.56	1.41	1.68	.34
E	56.11	.49	30.79	.99	.81	.88
F	56.95	.09	30.64	.76	.47	.59
G	56.11	.39	31.09	1.7	2.12	.51
H	57.29	.0	30.2	1.41	1.58	.40
I	56.95	.49	30.49	1.11	1.75	.73
Theoretical compound	58.55		31.39			

It will be observed that the samples are fairly uniform in composition and, when allowance is made for the moisture content, not far from the theoretical. The greatest variation occurs in the water-soluble arsenic content. As this characteristic is arbitrarily defined, the observed differences may be due to differences in physical nature or methods of manufacture.

The most recent development in the method of manufacturing Paris green is covered by a patent (Webster 1933) for a special air-floated product which is considerably finer than the other brands.

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F. E. DEARBORN, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*—7-23-37.

Vegetable Weevil, *Listroderes obliquus* Klug, Feeding upon Tobacco.—The vegetable weevil, *Listroderes obliquus* Klug, which now occurs in harmful abundance in Gadsden county, Fla., for the first time, has been found feeding upon tobacco. The infestation was first observed in a plant bed during the latter part of March. Larval feeding upon the tender outer leaves was extensive and frequent instances were observed where

the insect had eaten away the buds of the plants. The infestation increased during the first part of April and caused a considerable loss of plants in the portion of the bed attacked. Two fields of newly set tobacco were observed in which the larvae were feeding upon the plants. In each instance the insects had apparently been carried from the infested bed to the field upon the plants. While the infestation was small in scope, the plants attacked were severely injured.

This is apparently the first recorded instance of the vegetable weevil feeding upon tobacco in the United States. The insect has become well established in a tobacco-producing region for the first time and it may possibly become an economic pest of this crop. The only available reference of this insect feeding upon tobacco is given by T. McCarthy (1924), who reports that on one occasion he found the larvae of the vegetable weevil "feeding on the young tobacco plants in the seed beds" in New South Wales. In this publication the insect is referred to as the brown vegetable weevil, *Listroderes* (*Desiantha*) *nociva* French, now considered to be synonymous with *L. obliquus* Klug.

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F. S. CHAMBERLIN and A. H. MADDEN, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*—7-31-37.

Methods of Preserving and Studying Genitalia.—The scientific note by De Long & Davidson (1937) on the method of study and preservation of leafhopper genitalia in the April number of the JOURNAL leads me to offer the following additional suggestions.

Genitalia are best studied in a modified glycerin jelly made according to the following formula:

Water 42 cc.
Gelatin 6 gms.
Carbolic acid 2 gms.

Heat until the material dissolves, then dilute with glycerin according to temperature. One hundred to 25 cc. of the above stock solution is correct for a room temperature between 85 and 90° F.

If this glycerin jelly is properly made, it will hold the genitalia in any position. This is very much better than attempting to hold the genitalia in position by means of pins, pieces of microscope slides or other mechanical means. A little experimentation will give a jelly that has a consistency which will permit the free movement of the genitalia but at the same time will be firm enough to hold them after they are manipulated into proper position. Its only limitation is that the carbolic acid, which is used as a preservative, tends to corrode dissecting needles and scalpels unless they are promptly cleaned after use.

For permanent preservation, we transfer the genitalia to ordinary gelatin capsules, using a capsule according to the size of the insect. These capsules may be secured in various sizes from the smallest, number five, which holds one-tenth cc. to large veterinary capsules for the genitalia of Cicadas and other large insects. The genitalia are transferred from the glycerin jelly to 35 per cent alcohol, 70 per cent, 95 per cent, absolute alcohol and cleared in carbol-xylol. The small end of the gelatin capsule is filled about one-third full of balsam damar and the genitalia transferred to the balsam damar in the capsule. The capsule is then filled with balsam damar and the cover placed over it and the pin carrying the insect is inserted directly through the capsule. If the pin is inserted through the capsule and the cover, this together with the balsam makes about as near a perfect permanent mount as is possible to secure. If it is necessary to remove the genitalia for further study, the capsule may be readily removed from the pin, placed in carbol-xylol, dissolving the balsam, the genitalia transferred through the grades of alcohol to the glycerin jelly and when the study is completed, the reverse process places it again in perfect preservation.

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Z. P. METCALF, *University of North Carolina, Raleigh.*—6-25-37.

JOURNAL OF ECONOMIC ENTOMOLOGY
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Vol. 30 October 1937 No. 5

ENTOMOLOGICAL FORECASTING

THE growth of our profession is testimony of the remarkable progress which has been made by entomologists in developing control measures for injurious insects. Yet, these accomplishments should not be considered as ending the job. Forecasting injurious outbreaks is equal in importance to successful control measures, if not the ultimate objective. The general idea expressed in this statement is not new, and the number of instances is increasing where good forecasting has been accomplished.

Notable among the predictions which have been successful are those in connection with the Hessian fly, grasshoppers and chinch bugs. In the case of some insects, forecasting the possibility of outbreaks may prove to be a comparatively simple matter, while with other insects it may be very difficult and imperfect at best. Such a service necessarily has to develop slowly, as it should be based upon a large number of records of various types gathered by many entomologists.

Undoubtedly, many factors will need to be considered in studying the various causes contributing to specific outbreaks of certain species. Biological, climatological and ecological factors with their inter-relationships are involved. It may take years to build up a background of information that can be used in making forecasts regarding the occurrence of some of the insects in injurious numbers. It will be difficult for any one organization to handle such a project at present, but much can be learned from discussions of the subject. Organized effort and cooperative planning are needed. Systematic observations of the seasonal performance of economic plants and of weed hosts and their relation to each other, to insect infestation, and to climatic conditions are necessary.

The development of entomological forecasting is slowly but surely taking place. The coordinated systematic accumulation of data for study and analysis should begin as soon as possible. With such a background of information we yet may see the day when entomological forecasting based upon scientific information will become a highly specialized phase of our profession.

F. L. THOMAS.—8-25-37.

Review

Proceedings of the Twenty-fourth Annual Meeting of the New Jersey Mosquito Extermination Association. 1937. 236 pp., 31 figs. New Jersey Mosquito Extermination Association, New Brunswick, N. J. $1.

The "Proceedings of the New Jersey Mosquito Extermination Association" contains papers read before the annual meeting of the New Jersey Mosquito Extermination Association, one of the major meetings of mosquito control workers.

The papers present much practical information and considerable scientific data of interest to mosquito workers. Discussions of the papers are enlightening and afford an opportunity to learn of experiences elsewhere and of modifications of established mosquito control principles employed over a wide variety of sections. Mosquito control workers can ill afford not to peruse the present issue. Past copies should prove valuable as references.

An interesting topic presented is the protection from mosquitoes at outdoor meetings, an activity which would popularize any mosquito control campaign by affording temporary protection to outdoor public gatherings. Such protection would be especially valuable in demonstrating the desirability of mosquito-free environments.

A summary is given of work on mosquitoes throughout the world and should prove a boon to the busy worker who has little time to peruse the literature. Much contained in the summary is not available elsewhere, having been gathered direct by letter.

Valuable information is presented on directions for applying mosquito repellents for protection of outdoor gatherings; on the relation of mosquito prevalence to human comfort; the successful use of publicity in mosquito control campaigns; new and significant mosquito control developments in this country during 1936; the effect of rainfall on mosquito prevalence; studies of mass mosquito migration across open bodies of water; relation of mosquito control work to conservation activities, and other equally important subjects.

J. Lynne Robertson, Jr.—8-13-37.

Obituary

P. W. Claassen 1886–1937

P. W. Claassen

Professor Peter Walter Claassen was born March 17, 1886, on a farm near Hillsboro, Kans. He attended McPherson College, being graduated from the normal course, and taught in the Hillsboro schools, after which he entered the University of Kansas. He received his bachelor's degree from that university in 1913. During his undergradu ate days at Kansas he took major work in chemistry, which was most helpful to him in his later work, but on graduation he became assistant state entomologist of Kansas for two years, at the end of which period he was given his master's degree. He then entered Cornell University for further work in entomology and served as instructor for two years. He received his doctor's degree from Cornell in 1918, his thesis being an ecological study of insects in the cattail. He then remained at Cornell in charge of the course in elementary biology, which connection he retained until his death. During the academic year 1924–25 on leave from Cornell he reorganized the work in biology at Tsing Hua College, Peiping, China, to bring it to standard college grade. In 1917 he married Miss Evelyn Strong, who survives him with a son and daughter.

It is impossible for a close associate to write dispassionately of the death of this friend. "Pete," as he was known to his many friends and even to many students, was a fine, human personality. It would be impossible to believe that he had an enemy, and his devoted friends were myriad. He had the happy faculty of getting close to students, who worked hard for him, not as for a taskmaster but as for a companion. His lectures were interesting with touches of humor, but not to too great a degree so as to detract from

their thoroughness. His personal research was chiefly with Plecoptera, for which group he was an outstanding authority. His monograph on nymphs of this order is published by the Thomas Say Foundation, and shortly before his death he completed a catalog of the order which should appear shortly. He collected widely and had numerous correspondents who assisted with their findings, always in a friendly cooperation which was ideal.

His death on August 16 came unexpectedly, shortly after he and his family had completed a trip as far as the Pacific coast, on which he saw many old professional friends. While his closer friends had known for some time that his health was not all that might be hoped, the end came with scant warning. He was buried in a family lot at Auburn, N. Y. The loss of so capable a teacher is great to the institution with which he was connected and is irreparable to the multitude of friends in the local community and in a far wider circle, who held him in deep affection.

E. F. PHILLIPS.—9–9–37.

Dr. Vernon Lyman Kellogg, of the National Research Council, died August 8, 1937, at Hartford, Conn. Dr. Kellogg was for many years a member of the Association and a charter member of the Entomological Society of America. It is hoped that an obituary of Dr. Kellogg will be available for publication in the December issue of the JOURNAL.

Current Notes

ENTOMOLOGY DEPARTMENT AT CLEMSON IN NEW QUARTERS

ON April 1, 1937, the entomology department at Clemson, South Carolina's A & M College, moved into a beautiful new building along with several other departments in the School of Agriculture. Since 1924, when Clemson's agricultural hall was burned, the School of Agriculture has occupied space here and there in almost every building on the campus, and under these conditions progress in teaching and research was greatly hindered. In the new building, Long hall, are the offices of the dean of agriculture, the teaching and research phases of the horticulture, poultry, entomology, botany, agricultural economics, agronomy, and farms departments. In addition the entire agricultural extension service occupies space in the new structure.

The entomology department occupies approximately half of the second floor and in addition to private offices and adequate classroom and laboratory space the department is provided with a museum room and a small departmental library. Along with the new building a very substantial amount of new equipment was purchased for classrooms and laboratories which include 110 Cornell-type insect drawers in metal storage cabinets for the museum.

THE thirteenth National Shade Tree Conference was held in Baltimore, Md., September 1–3, 1937. The program consisted of talks, a field demonstration, exhibitions and entertainment. G. F. MacLeod, S. W. Bromley, C. C. Hamilton, J. S. Houser, L. H. Worthley, G. S. Langford and E. N. Cory presented papers before the meeting. C. C. Hamilton and E. N. Cory served as chairman at the time of several of the regular program sessions.

ANOTHER edition of "Entoma," a directory of insect pest control, has been published by the Eastern Branch of the American Association of Economic Entomologists, under the editorship of C. C. Hamilton. The price of this publication is 75 cents to domestic, and 81 to foreign purchasers. All correspondence pertaining to this publication should be directed to C. C. Hamilton, department of entomology, Rutgers University, New Brunswick, N. J.

This directory was prepared to assist entomologists and others interested in insect control in obtaining certain kinds of information which have heretofore been somewhat difficult of access. This booklet is practically indispensable to the working entomologist in the field of insect control.

UPON his return this spring from a six months' leave of absence for study and collecting in the tropics, Dr. S. W. Frost, who has been associated with Pennsylvania State College for 19 years, was called from his station at Arendtsville, Pa., to State College, to be the new head of the department of entomology, and have charge of all undergraduate and graduate study in entomology.

TOBACCO INSECT COUNCIL ORGANIZED

On July 7 and 8, 1937, a conference of entomologists interested in work on the control of tobacco insects was held at Florence, S. C., and the Tobacco Insect Council was organized. This Council was affiliated with a group of plant pathologists interested in the study of tobacco diseases and agronomists engaged in research on tobacco fertilizers and cultural methods. It is apparent that in producing a crop of high quality tobacco many interrelated problems exist, and annual meetings scheduled to be held jointly by these groups of workers are expected to bring about a desirable coordination of effort.

A joint meeting with the plant pathologists was held on July 7, and on July 8 the entomologists met in a round table discussion of the work on tobacco insects.

W. D. Reed served as chairman and S. Marcovitch as secretary of the Council at the Florence meeting; these officers were elected to serve also at the 1938 meeting.

PAPERS

Use of Fluorine compounds in control of tobacco insects, S. MARCOVITCH.

Flea beetle damage in North Carolina in 1937, W. A. SHANDS.

Flea beetle damage in Virginia in 1937, W. J. SCHOENE.

Review of chemotropic experiments for control of hornworm moths, L. B. SCOTT and J. U. GILMORE.

Control of flea beetles on cigar types of tobacco, F. S. CHAMBERLIN.

Suggestions for making an annual survey of tobacco insects and diseases, W. D. REED.

Research on tobacco insects from funds obtained under the Bankhead-Jones bill, W. J. SCHOENE.

COMMITTEES

Tobacco Flea Beetle—W. J. Schoene, *chr.*, W. A. Shands, E. N. Cory, F. S. Chamberlin.

Tobacco Insect Survey—W. C. Nettles, *chr.*, C. T. Rowell, W. W. Stanley, L. B. Scott, W. E. Britton, H. H. Jewett, W. A. Shands.

Tobacco Recommendations—W. D. Reed, *chr.*, W. J. Schoene, S. Marcovitch, F. S. Chamberlin, W. A. Shands, L. B. Scott, W. C. Nettles.

PRESENT

Allen, Norman, Florence, S. C.
Barss, H. P., Washington, D. C.
Chamberlin, F. S., Quincy, Fla.
Clayton, E. E., Washington, D. C.
Marcovitch, S., Knoxville, Tenn.
Nettles, W. C., Clemson College, S. C.
Schoene, W. J., Blacksburg, Va.
Scott, L. B., Clarksville, Tenn.
Shands, W. A., Oxford, N. C.
Stanley, W. W., Knoxville, Tenn.
Watts, R. L., Florence, S. C.
White, W. H., Washington, D. C.
Reed, W. D., Richmond, Va.

H. P. Barss, Assistant Director, Office of Experiment Stations, attended the organization meeting of the Council and contributed some timely and helpful suggestions.

S. MARCOVITCH, *Secretary*

DEAN AND NABOURS HONORED UPON TWENTY-FIFTH ANNIVERSARIES AT KANSAS STATE COLLEGE

George A. Dean and R. K. Nabours, heads respectively of the departments of entomology and zoology, Kansas State College, Manhattan, were honored on October 1 and 2 for their rounding out of 25 years as heads of their departments. Dr. Paul S. Welch, member of the Kansas State College entomological staff from 1913 to 1918, gave an invitation address October 1 on "The oxygen balance in inland waters and the hazards of aquatic respiration," as part of the two-day program in honor of the two scientists.

Open house, displaying major accomplishments of the last 25 years and research now in progress, was held for the two anniversary days. Bound volumes of letters from students and friends were presented to Professors Dean and Nabours at the banquet held Saturday evening, October 2. Bulletins were also distributed which recounted the quarter century of work by the two men and listed titles of all published papers from the two departments.

A considerable number of friends, former students and graduates attended the honoring exercises.

L. A. STRONG, Chief of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, presented a paper entitled "Nurserymen and Quarantines" before the sixty-second annual meeting of the American Association of Nurserymen at Chicago, Ill., on July 15, 1937.

DR. P. N. ANNAND has been made special research assistant to the chief of the Bureau of Entomology and Plant Quarantine, Washington, D. C. He will be succeeded as chief of the division of cereal and forage insect investigations by C. M. Packard.—*Science* **86** 2229):264, September 17, 1937.

HARLAN N. WORTHLEY, professor of economic entomology at Pennsylvania State College, is on leave of absence until June 1938. He will pursue graduate study and research in insect toxicology under Dr. F. M. Campbell in the department of zoology and entomology, Ohio State University.

REGIONAL GRASSHOPPER AND MORMON CRICKET CONFERENCE HELD AT SIOUX FALLS, S. D., AUGUST 26

THIRTEEN states were represented at a Regional Grasshopper and Mormon Cricket Conference called by the Governor of South Dakota at Sioux Falls on August 26. A. M. Eberle, Director of Extension of the South Dakota State College, acted as chairman, and the meeting was conducted jointly by the college and the Greater South Dakota Association. The thirteen states represented were California, Illinois, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, Oklahoma, Wisconsin, Wyoming and South Dakota. A definite plan of procedure was adopted for a large area including all the states west of and including Michigan, Illinois, Missouri, Arkansas and Texas.

Among the federal entomologists in attendance at this conference were J. R. Parker, F. D. Butcher and R. L. Shotwell. Dr. Parker outlined the 1937 federal control campaigns and F. D. Butcher related some of the weaknesses encountered from the federal angle. R. L. Shotwell explained the fall adult and egg survey plans. Five-minute reports were made by representatives of the state extension service, the grain trade, the farmers, the business men, the railroads and the bankers. Dr. H. C. Severin discussed the "Natural Enemies of Grasshoppers," Dr. Corkins the "Importance of Pest Control Districts," and S. C. Campbell, "Grasshopper Control by Egg Destruction."

Moving pictures of "1937 Infestation and Control Methods for Grasshopper and Crickets" were shown at a banquet held Thursday evening, at which time the committee reports were received and acted upon.

The committee on legislation was A. G. Ruggles, Minnesota, *chr.;* E. H. Sexauer, South Dakota; B. E. Groom, North Dakota; John Haw, Minnesota; C. L. Corkins, Wyoming, and Geo. D. Jones, Missouri.

The following were on the committee on education: Geo. C. Decker, Iowa, *chr.;* E. G. Kelly, Kansas; Sam C. McCampbell, Colorado; F. A. Fenton, Oklahoma; Myron H. Swenk, Nebraska; Fred D. Butcher, Washington, and Wilkie Collins, South Dakota.

REPORT OF THE COMMITTEE ON EDUCATION

This Conference holds the conviction that grasshopper control is a permanent factor in North American Agriculture, at least in the west, and especially in the great plains area. Grasshopper populations will of course wax and wane more or less, in response to varying fundamental environmental conditions, but they nevertheless will continue year after year to destroy or menace crops somewhere, regardless of natural control, and annual surveys, both of adult grasshopper populations in the late summer and of grasshopper egg depositions in the fall, will continue to be requisite as a basis for the planning of control measures for the following year.

Experience has shown that a general conference following the completion of the egg survey, at which the results secured in the several states may be reported, studied and discussed, and used as a basis of such control planning, is exceedingly helpful if not absolutely necessary. Such conferences held in the past to date have been called more or less suddenly and spontaneously, some state assuming the initiative in sending out the call, perhaps without the fullest opportunity for an expression from all of the interested states as to the most convenient locality and date. We therefore recommend that a permanent Grasshopper Control Committee be set up at this Conference, on which each state west of and including the states of Michigan, Illinois, Missouri, Arkansas and Texas may have one

representative, preferably the state leader, under a chairman to be elected annually by these representatives, which committee shall ascertain the convenience of the several states in this matter and call the conference each year in conformity with the prevailing sentiment of these expressions of convenience.

This Conference believes that adequate education is fundamental to the successful application of insect control measures and that means should be found further to extend entomological education to farm operators, pest district leaders, foremen of mixing plants, county agents and the public generally. Such entomological education should include fundamental education on the habits and life histories, physiology and ecology of injurious insects as well as empirical information on formulae and methods of procedure. The state leaders in grasshopper control are usually fully occupied at headquarters during the active period of a campaign with the details of the allotment and distribution of the poisoned baits within the state and the maintaining of the necessary contacts with the federal offices, and have little or no opportunity personally to contact the mixing plant operations and the use of the bait by the farm operators. The time of the county agent is usually fully taken with a multiplicity of duties aside from grasshopper and other pest control work, so that he can give the matters of education and supervision but little personal attention.

We therefore recommend that, in view of the high values of bait material concerned, and the dangers involved in the use of highly poisonous materials, ordinary good judgment and economy indicate that more assistant state leaders and pest control assistants to county agents be employed, using any moneys that can be found, from federal, state or county funds, to pay such additional assistants. Appointments of this kind should be approved by the state leader as to the competence of the appointee to provide proper education and correct information as to insect biology and control, and such appointees should serve as agents of the state leader to establish contact between his office and the field control operations.

Members of this Conference have commonly observed that those county agents who have had even an elementary course in entomology are much more efficient in pest control campaigns of any kind than those without such training. We recommend that the extension directors of the various states who employ county agents endeavor to engage only men for these positions who have had a course in entomology amounting to at least three semester credit hours or their equivalent, and wherever possible set this as a prerequisite for employment in such positions.

Your committee recommends that the entomological agencies within the grasshopper-infested states should be sure that all educational units operating within the state be advised of recommendations being made by the state leader of grasshopper control. This procedure will insure uniform statements throughout the state. In connection with publicity articles, your committee recommends that care should be exercised not to disagree forcefully with suggestions being published by nearby states.

The committee recommends that information on grasshopper control be given to all agencies in each state that are in direct contact with the agricultural public, such as the Soil Conservation Service, Agricultural Conservation Program, and Resettlement Administration, so that there will be no conflict in recommendations and a greater number of people will be reached.

The discussion at this Conference indicates that cultural practices and mechanical spreading of bait are important phases of grasshopper control, and your committee recommends that state leaders in cooperation with other responsible agencies outline cultural procedures adapted to local conditions in their respective states, and further suggests the need for the extended use of spreading machines. Your committee believes demonstrations with bait spreading machines are well worth while.

This committee recommends that all research and educational institutions collect, study and publish sound factual information that will refute many of the erroneous reports in current circulation and such unsound practices as the artificial distribution of fungus, burning of cover for the destruction of eggs and the use of ineffective insecticides.

Since visual education is now well established and projecting and moving picture equipment is generally available, we recommend a more generous allotment of funds for the expedient production of high-grade educational moving picture films, slide sets and film strips.

Since each year there seems to be a lack of information concerning why grasshopper bait may be furnished to farmers at different handling charges in different localities, it is recommended that complete information as to the basis of such charges be made available to those interested.

The formulation of a broad, comprehensive educational program, a task that will require much time and effort, was obviously beyond the duty of this committee. We recommend, however, the appointment of a special committee to study this problem and report its findings to the next grasshopper control conference.

REPORT OF THE COMMITTEE ON LEGISLATION

We recommend that the 1938 Congress establish, and subsequent Congresses maintain, a fund of five million dollars, to be replenished to the original amount at the beginning of each fiscal year whenever such replenishment is necessary, to be available to and administered by the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture for the financing through advance options, or storage, and subsequent distribution to the affected states, through cooperation with the proper officials of the states concerned and upon adequate set-off commitments of these states, of insecticides and other usable materials, equipment, transportation, distribution and application, administrative costs and other expenses incidental to accomplishing the control of grasshoppers, chinch bugs, and other insect pests similarly subject to interstate migratory movements, or intermittent regional outbreaks affecting several states (but exclusive of purely intrastate or local outbreaks), or emergency insect outbreaks that threaten the agricultural interests of several states, if and when the need and desirability for such federal aid is satisfactorily established through the approval of competent technical committees, the Secretary of Agriculture and other proper governmental agencies; and

We urge that the Congress seriously consider the need of an appropriation greater in amount than that needed for current seasonal operations in order that there may be a sufficient residue of funds available in reserve to finance early seasonal work the following spring prior to the availability of a new Congressional appropriation.

We recommend that the appropriation bill for grasshopper and Mormon cricket control carry authorization for the use of not to exceed 15 per cent of the appropriation for educational and supervisory work.

We recommend that the U. S. Bureau of Entomology and Plant Quarantine increase its budget item of 1938 for cooperative state-federal grasshopper egg surveys to $40,000 and urge the approval of this item by the Bureau of the Budget and the Congress.

We urge that the delegates of states of this Conference, immediately following this meeting, arrange for suitable contacts with their state Congressional delegations on the legislative matters developed by this Conference, and to continue to place timely grasshopper and Mormon cricket survey and predictions information before them, seasonally, under the coordinated plan of the legislative committee.

We recommend that the chairman of this Conference appoint a permanent legislative committee of three for the purpose of translating this program into actuality.

SPECIAL RESOLUTION

The following special resolution was adopted on recommendation of farm groups in attendance at the conference:

WHEREAS the farm operators of grasshopper infested areas in the various states are cognizant of an existing and impending grasshopper menace and are anxious to cooperate with state and federal agencies in a program of egg destruction through cultural practices adapted to local conditions this fall as recommended by the Sioux Falls grasshoppers conference of August 26, 1937; and

WHEREAS the finances of many of these operators do not permit participation in this program without federal assistance, thereby creating an emergency situation requiring immediate attention; therefore be it

RESOLVED that financially distressed farmers in grasshopper infested counties as disclosed by egg surveys receive special benefit payments from the Agricultural Conservation Service or from some other federal agency to carry on cultural practices which will effectuate control of grasshoppers as well as soil erosion.

E. L. CHAMBERS

Dr. L. E. ROZEBOOM has been appointed associate professor of entomology in the Entomology Department of Oklahoma A. & M. College to fill the vacancy caused by the retirement of Professor C. E. Sanborn. Dr. Rozeboom will have charge of the project on insect transmission of bovine anaplasmosis.

Horticultural Inspection Notes

REVISION of the federal quarantine relating to the black stem rust, which became effective September 1, 1937, adds the states of Missouri, Pennsylvania, Virginia and West Virginia to the list of states designated as protected in notice of Quarantine No. 38 as revised effective August 1, 1931. Under the recent revision, the interstate movement of all barberry and Mahonia plants, except the Japanese barberry, *Berberis thunbergii*, and its rust-resistant varieties, into or between the four above states, as well as into or between the 13 states previously designated as protected states, is restricted.

STATE quarantine relating to the phony peach disease, standardized according to the recommendations of the quarantine committee of the Southern Plant Board, have been adopted by Alabama, Georgia, Illinois, Louisiana, North Carolina and Tennessee.

THE tomato pinworm quarantine issued by the Idaho Commissioner of Agriculture on June 17 applies to the states of Pennsylvania, Florida, Virginia, Delaware, Mississippi, New Mexico, California, Missouri, Texas, Arizona, Utah and also to Mexico and Hawaii. Fumigation is required before shipping tomatoes and tomato plants from the above areas.

QUARANTINES relative to the serious new pest known as the white fringed beetle, *Naupactus leucoloma* Boh., have been established by the states of Florida and Alabama, regulating the movement of host materials from the infested counties of Walton and Okaloosa, in Florida, and Covington and Geneva, in Alabama. A new center of infestation by this weevil has also been discovered more recently at Laurel, Miss. The articles of restricted movement, under the quarantines, include soil, nursery stock, hay, corn, beans, peas, potatoes, sweet potatoes, sugar cane, peanuts, chufus, cotton, picking bags, forest products, farm implements and scrap iron.

CHANGES were made in the treatment required for infested narcissus bulbs, as a condition of certification for shipping, in a revision of the Washington State Quarantine (No. 3) issued August 3, to become effective December 1, 1937. Narcissus grown for two successive seasons without thermal treatment are refused certification, and such bulbs shipped to Washington from any source outside the continental United States must receive hot water treatment.

ARKANSAS state inspection officials announce that under Act. No. 203 of 1937, which became effective July 1, 1937, a bond is no longer required of nurserymen doing business in that state, except that the Plant Board is empowered to require a bond of nurserymen resident in such states as require a bond of Arkansas nurserymen. Licenses may be revoked, under the above amendment, for repeated substitution of varieties, and for misrepresentations.

CHANGES in New Mexico laws and regulations in 1937 which affect the nursery inspection activities include the requirement of a $10 fee from out-of-state nurserymen; restrictions as to the entry of nursery stock and soil from parts of seven states on account of the Texas root rot, with similar restrictions as to intrastate movement from infected parts of New Mexico; restrictions on the entry of red cedar; and the placing of a standardized quarantine relating to the peach mosaic disease in that state. Quarantines are also maintained against the sweetpotato weevil and the alfalfa weevil.

RECENT action on the part of the Mississippi State Plant Board included the cancellation of the rule relating to anthracnose and wilt of cotton, and the quarantining of parts of five Mississippi counties on account of the sweetpotato weevil.

THE NEBRASKA Insect Pest and Plant Disease Eradication Law as amended in 1937 modifies the fee for nursery inspection and provides a minimum fee for the inspection of woodlands in the case of persons collecting and selling native plants.

ALL RULES and regulations of the Office of the Georgia State Entomologist which were in effect on March 25, when the Entomology Act of 1937 was passed, are continued in force under an order issued by the entomologist on April 2.

Pacific Slope Branch

REPORT OF THE TWENTY-SECOND ANNUAL MEETING

Denver, Colorado, June 24–25, 1937

The Pacific Slope Branch of the American Association of Economic Entomologists held its twenty-second annual meeting at Denver, Colo., Thursday and Friday, June 24–25, 1937. During its sessions 22 papers were presented. These included a number on grasshoppers and grasshopper control.

Dr. C. P. Gillette gave an interesting invitational address on "Adaptation to Environment in Super-family Aphoidea."

The entomologists' dinner was held Thursday evening, at which the members were addressed by C. P. Gillette and R. A. Cooley.

Total attendance at the meetings was 45. Officers elected for 1938 are J. R. Eyer, State College, N. M., *chr.;* W. C. Cook, Modesto, Calif., *vice chr.;* and J. F. Lamiman, University of California, Davis, Calif., *sec'y-treas.*

J. F. LAMIMAN.—*Secretary.*